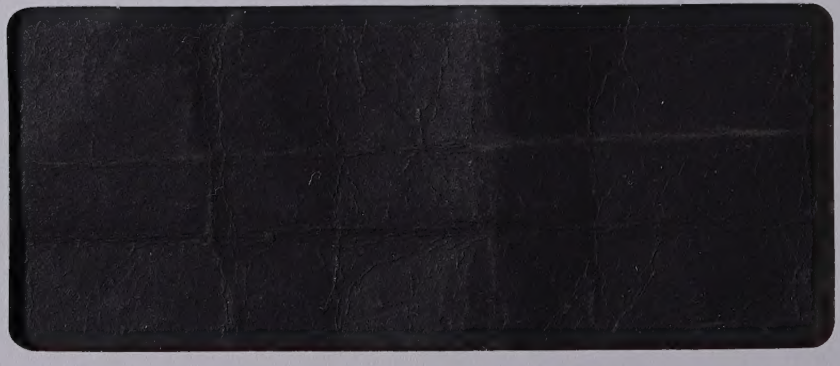
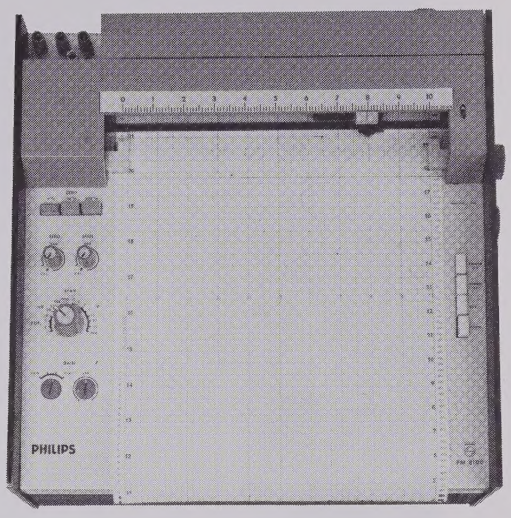
709

PHILIPS





PHILIPS

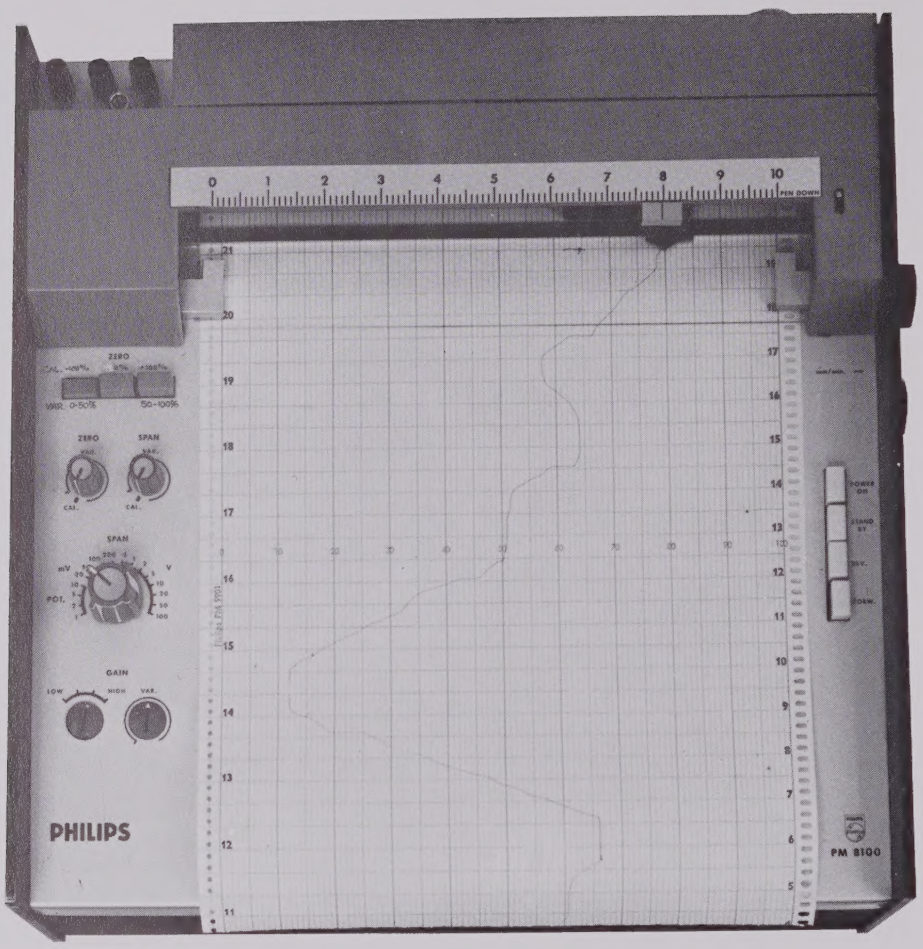
MANUAL

FLAT-BED RECORDER

PM 8100/06/07/08

9443 081 000.1

9499 430 01111 15/1270



© N.V. PHILIPS' GLOEILAMPENFABRIEKEN - EINDHOVEN - THE NETHERLANDS

CONTENTS

DIRECTIONS FOR USE

I. INTRODUCTION 5

II. TECHNICAL DATA 6

III. STANDARD ACCESSORIES AND REMOVING OF THE TRANSPORT LOCKING DEVICES 9

IV. CONNECTION DATA 11

V. PUTTING INTO OPERATION 18

VI. MAINTENANCE 23

VII. OPERATING PRINCIPLE 24

SERVICE

VIII. TROUBLESHOOTING 26

IX. AMPLIFIER CHECK 27

X. MEASURING BRIDGE CURRENT CHECK 32

XI. INPUT UNIT CHECK 33

XII. REPLACING THE DRIVE CORD 37

XIII. MOTOR GENERATOR UNIT 40

XIV. MEASURING CARRIAGE 43

XV. MEASURING POTENTIOMETER 44

XVI. CHART DRIVE MECHANISM 45

XVII. THE VERSION FOR 60 c/s (PM 8100/Q.) 47

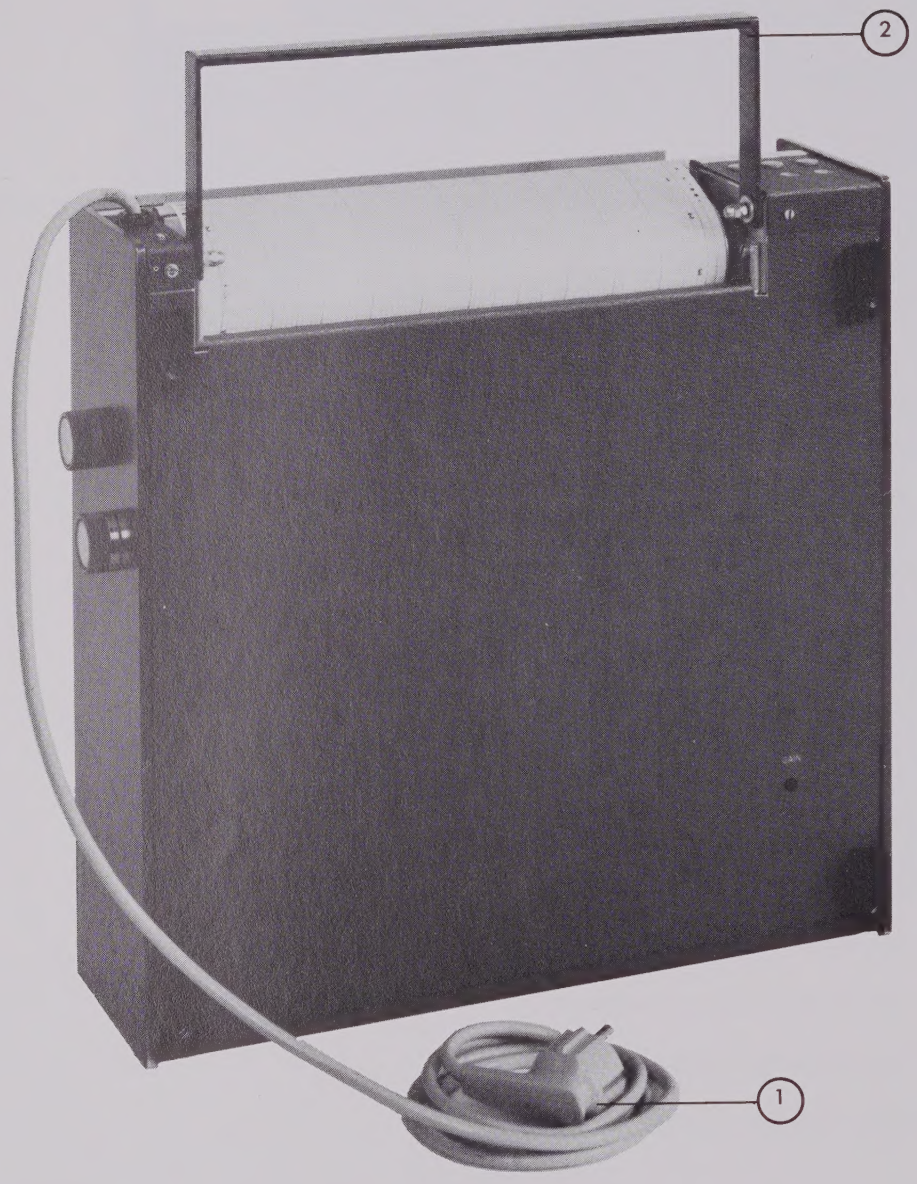


Fig. 1

I. INTRODUCTION

The Philips flat-bed recorder type PM 8100 serves for measuring and recording d.c. voltages in the mV and V ranges. The application range can be easily extended to the measuring of temperatures with the aid of thermocouples and the measuring of current strengths up to the measurements whereby the amount to be measured can be converted into a suitable d.c. voltage. The working of the recorder is based on the principle of automatic compensation of the unknown voltage by means of a servomechanism.

The measuring range can be set in 16 steps from 1 mV to 100 V full-scale in the 1-2-5 series. In the positions 20 mV to 100 V it is possible to increase the set measuring range maximum by a factor 2.5 to 3 by means of a continuous adjustment. The measuring circuit has three calibrated zero points i.e. -100 %, 0 % and +100 % although it is possible to adjust the zero point continuously between -10 % and +115 % of the full-scale.

The chart drive mechanism is provided with a 10 speed gearbox.

The flat-bed recorder is provided with a mains connecting cord (Fig. 1, item 1) with universal contact stop (EURO) and earth rim and with a (fold out) carrying handle, (item 2) with which the instrument can also be placed on a table below an angle of approx. 15^{o}.

The instrument can be mounted in a 19" frame:

- Vertically with the aid of the mounting plate PM 9806
- Horizontally by using the drawer PM 9808

The standard version of the flat-bed recorder can be equipped with a two position event marker type PM 9802 and a slave potentiometer type PM 9803.

The event marker should fix the period of time of something happening or being treated during the recording.

The slider of the slave potentiometer is coupled with the measuring carriage of the recorder. If a supply voltage is connected on the slave potentiometer, the slider contact will give a voltage which is proportional to the displacement of the measuring carriage.

II. TECHNICAL DATA

A. FOR THE STANDARD RECORDER

Measuring system	automatic compensation with the aid of a servomechanism
Measuring ranges	multiple calibrated measuring range, adjustable on 1 mV, 2 mV, 5 mV, 10 mV, 20 mV, 50 mV, 100 mV, 200 mV, 500 mV, 1 V, 2 V, 5 V, 10 V, 20 V, 50 V, 100 V full-scale deflection. In the positions 20 mV to 100 V the set measuring range can be increased max. by a factor 2.5 to 3 by means of the potentiometer "SPAN"
Accuracy	0.25 % of the full-scale deflection
Reproducibility (including dead band and drift)	0.1 % of the full-scale deflection
Zero point adjustment	calibrated adjustments possible on -100 %, 0 % and 100 % of the full-scale deflection; adjustable setting possible from -10 % to +115 %
Reference current	1 mA, stablised by zener diode with temperature compensation
Balancing time	less than 1 sec. for full-scale deflection
Source impedance	max. source impedance for measuring ranges from 1 mV to 10 mV: 5 kΩ/mV range for measuring ranges 20 mV and higher practically no limitation of source impedance.
Input current in compensated condition	⩽ 0.2 nA with max. source impedance for measuring ranges from 1 mV to 10 mV
Input impedance	5 kΩ for measuring ranges from 1 mV to 10 mV not compensated. 100 kΩ for measuring ranges from 20 mV to 200 mV 1 MΩ for measuring ranges from 500 mV to 100 V
Permissible interference voltages asymmetrical interference a.c. voltage (common mode)	for the measuring ranges from 1 mV to 10 mV: 5x measuring range (66 dB)
symmetrical interference a.c. voltage (series mode)	10x measuring range (72 dB)
asymmetrical interference d.c. voltage (common mode)	1000x measuring range (112 dB)
Insulation resistance	> 5000 MΩ between input terminals and earth
Max. permissible voltage	100 V~ or 150 V ⎓ between input terminals and earth
Overload on the input	input is protected against overload

Amplification ("GAIN")	for the measuring ranges 1 mV to 10 mV: control on the front with coarse and fine adjustment. With constant source impedance the amplification is automatically adjusted with changing over to another measuring range. For measuring ranges of 20 mV and higher the amplification is critically adjusted on delivery and is independent of the source impedance
Measuring potentiometer	- right spindle, resistance 300 Ω ± 0.1 % - linearity 0.1 % - recording pen directly coupled with measuring potentiometer
Chart drive mechanism	- forward and reverse - 10 speed gear box: 0.5-1-2.5-5-10-25-50-100-250-500 mm/min
"STAND BY" switch	pushbutton control for switching off servomotor
Writing system	- recording length approx. 1500 m per cartridge - pen can be lifted manually from chart
Dimensions	- height 130 mm - width 390 mm - length 390 mm
Weight	approx. 13 Kg
Ambient temperature	$20^{o}C \pm 25^{o}C$
Mains voltage - for standard recorder - for version PM 8100/Q	 110 V - 220 V - 245 V (-15 % to +10 %) 50 c/s ± 5 % idem for 60 c/s ± 5 %
Power consumption	approx. 15 VA

B. FOR THE ACCESSORIES

Event marker type PM 9802	- electromagnetic working - deflection of marking pen by external shortcircuit contact - marking on left side of chart outside perforations - writing system same as that of recorder
Slave potentiometer type PM 9803	- "multiturn" potentiometer - resistance 1000 Ω ± 3 % - linearity ± 0.25 % - resolution 0.046 % - power 4.75 W
Mounting plate type PM 9806	the recorder is mounted vertically in a 19" frame with this
Drawer type PM 9808 (Fig. 2)	the recorder is slid horizontally into a 19" frame with this
3 ink cartridges type PM 9805	filled with red ink, nylon nib
3 ink cartridges type PM 9807	filled with green ink, nylon nib

3 ink cartridges type PM 9809 without ink, steel capillary, with injector.
ink PR 7743/20 possibly to be used

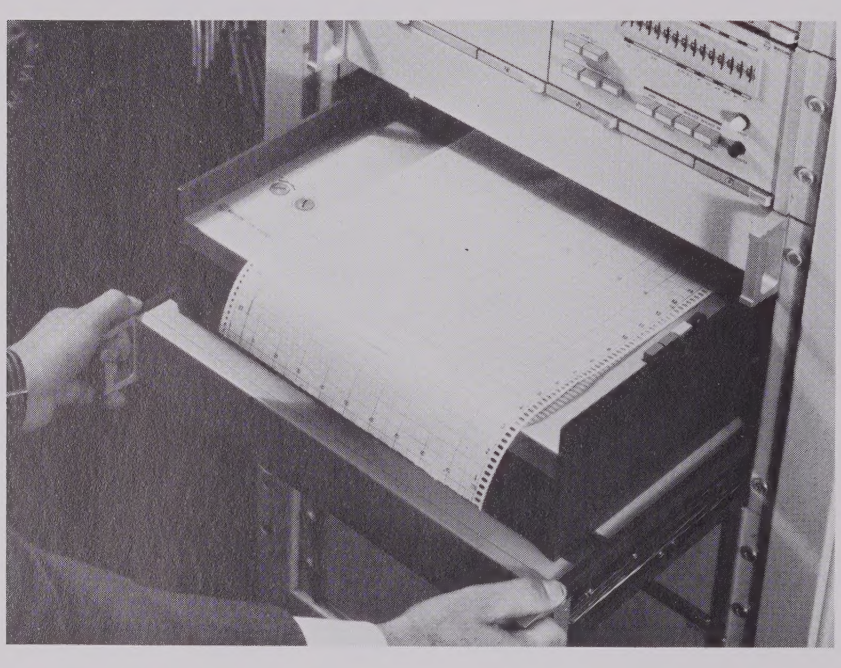


Fig. 2

III. STANDARD ACCESSORIES AND REMOVING OF THE TRANSPORT LOCKING DEVICES

Fig. 3 gives a survey of the accessories packed separately with the recorder.

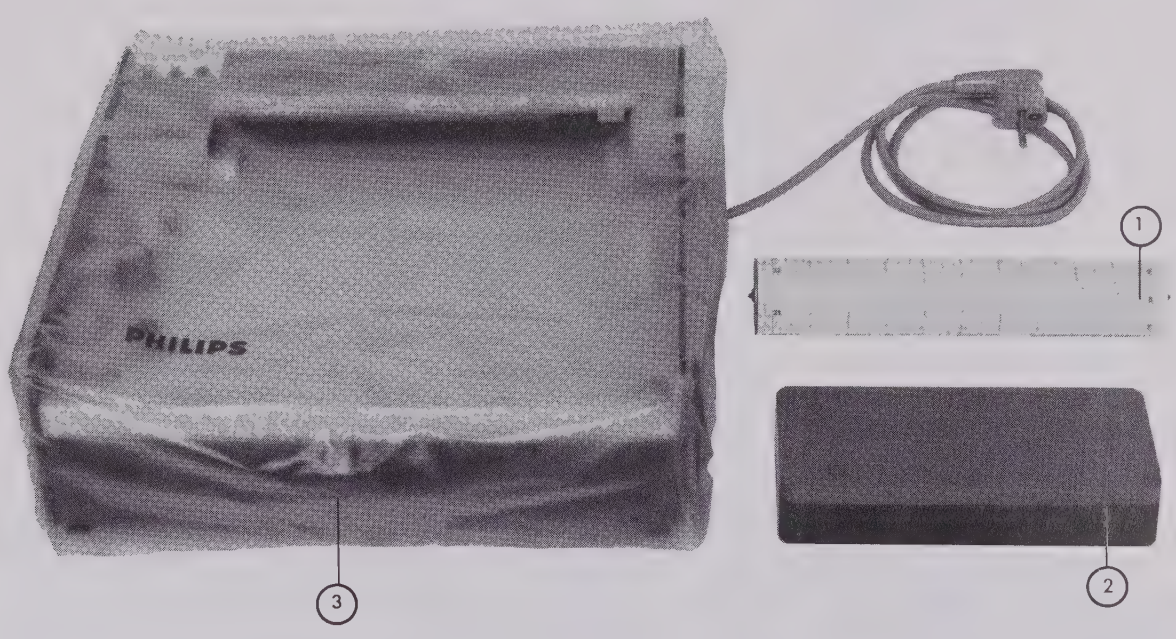


Fig. 3

item 1 - the supply roller (code number 4822 535 70268) on which is mounted the roll of recordering chart, type PM 9901 with linear division from 0 to 100 and with zero point on 0 %.

item 2 - service kit (code number 4822 310 30336), containing:

- . 3 ink cartridges, 2 red and 1 green
- . a bottle of lubricating oil Shell Tellus 27; on command a bottle of oil is supplied, contents 50cc, under code number 4822 390 10022.
- . a bellows, code number 4822 418 60011
- . a brush and a soft brush
- . 2 fuses 200 mA code number 4822 253 30012
- . 2 fuses 400 mA code number 4822 253 30016 for PM 8100/Q
- . 2 fuses 32 mA code number 4822 253 30001

item 3 - dust cover, code number 4822 600 30001

The above parts can be ordered under the given code and type numbers resp.

To prevent damaging during transport, the following parts are secured with adhesive tape and a string resp.

- control button for pen lifting	Fig. 4, item 1
- tearing string	Fig. 4, item 2
- carrying handle	Fig. 4, item 3
- protective cover	Fig. 4, item 4
- guiding device	Fig. 4, item 5
- measuring carriage	Fig. 4, item 6

The secures named should be removed before the instrument is put into use.

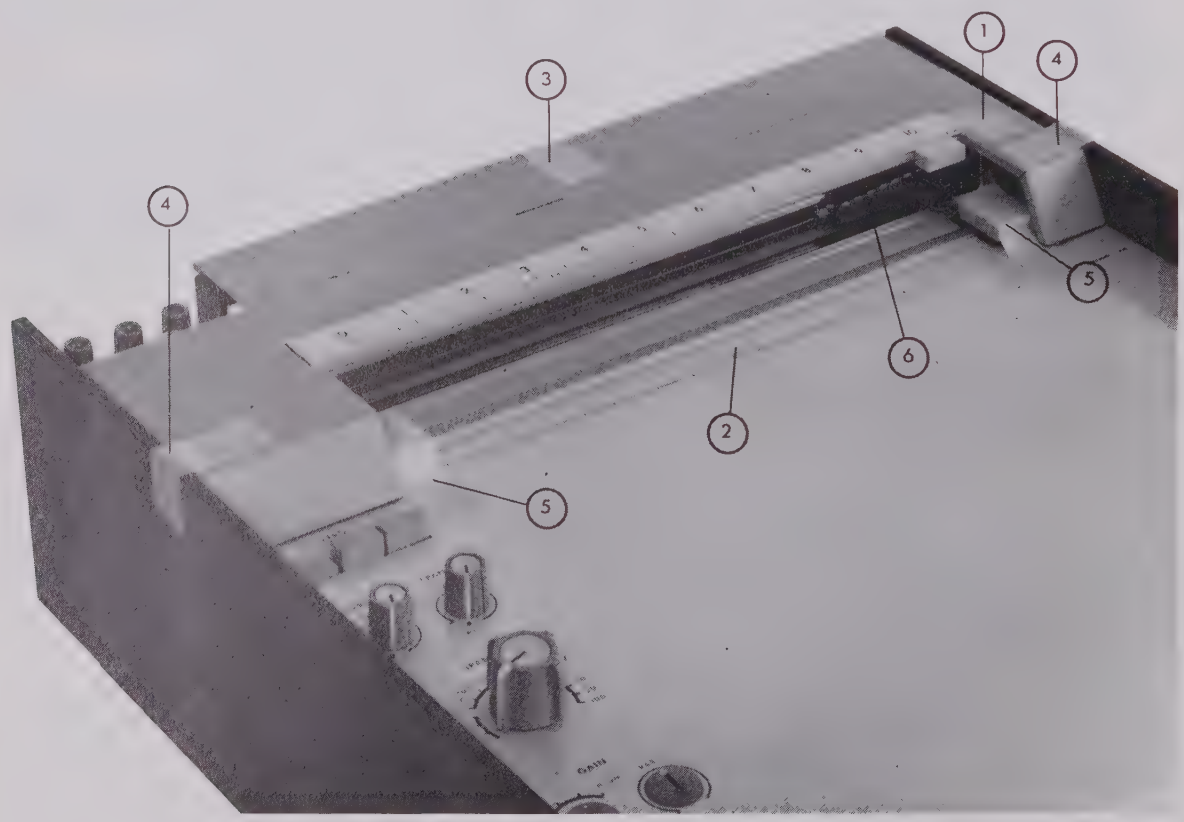


Fig. 4

IV. CONNECTION DATA

N.B. Check the correct position of the measuring range selector switch ("SPAN") Fig. 5, so that overload of the measuring system is prevented. The measuring system is protected against overload by a 32 mA fuse, Fig. 6 item 1 (accessible after rear plate is removed).

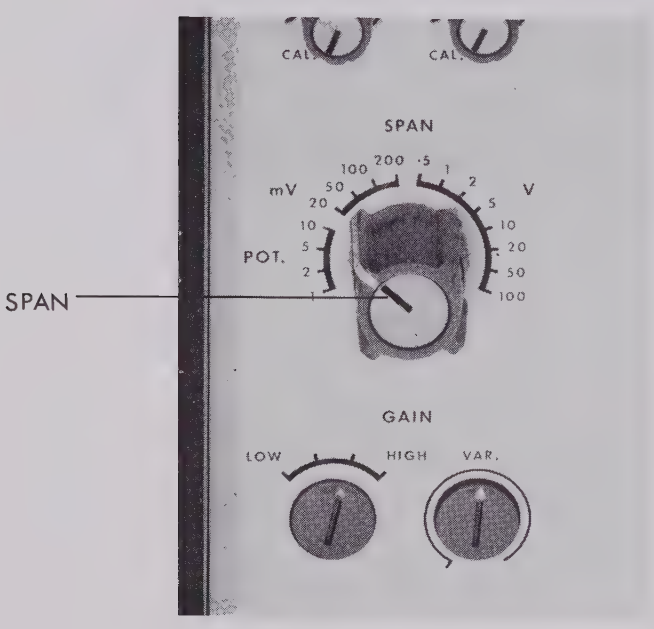


Fig. 5

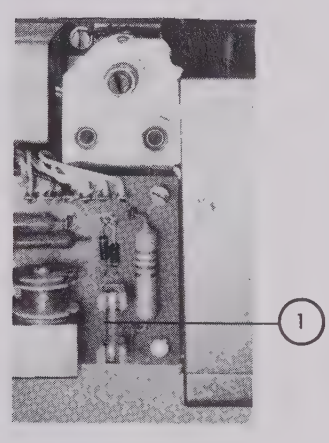


Fig. 6

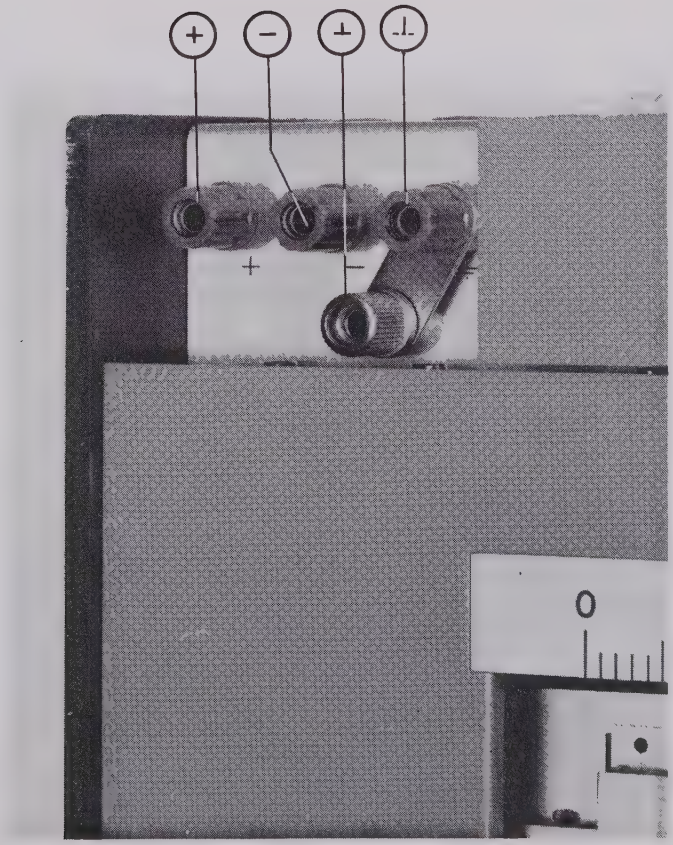


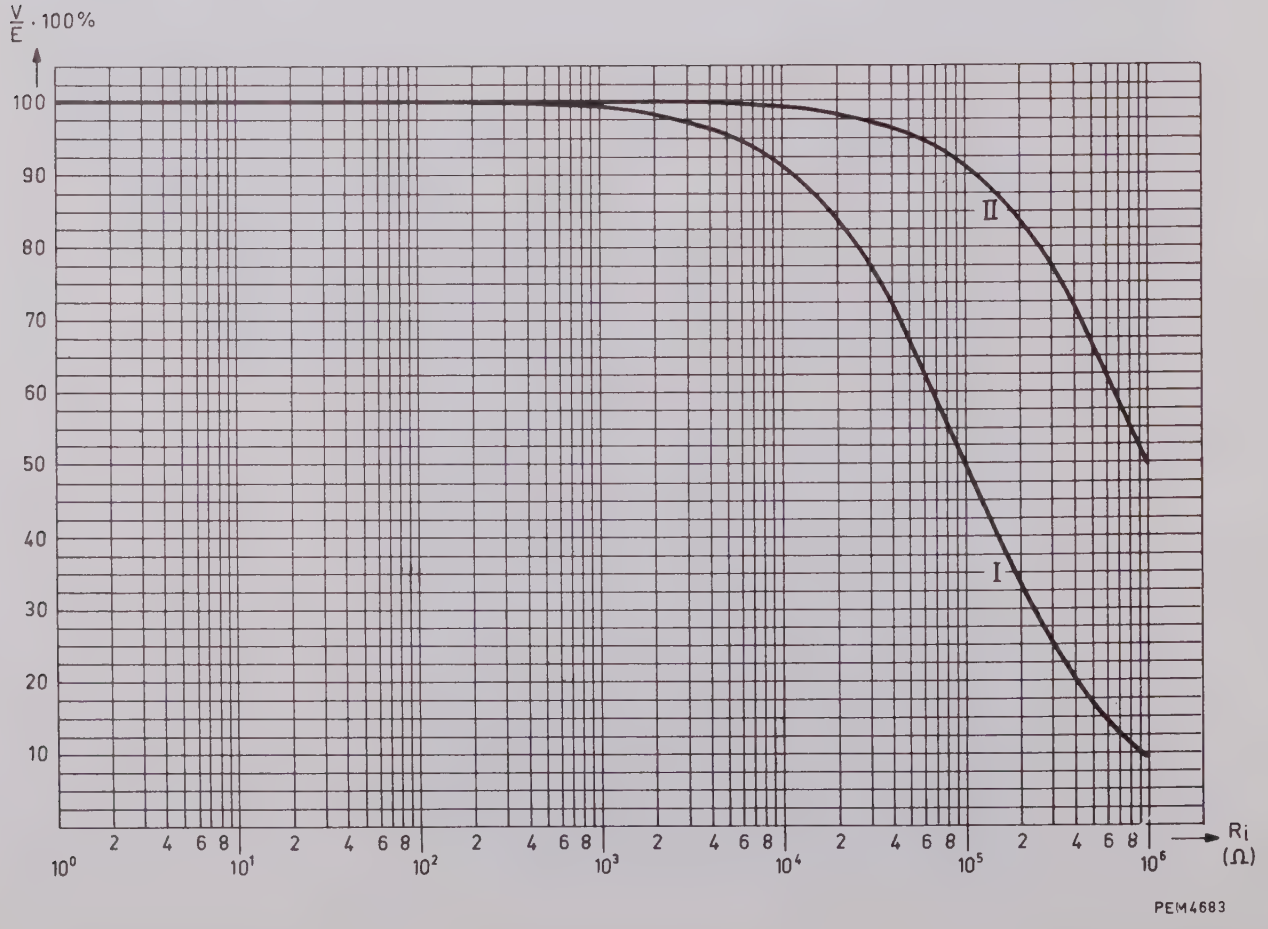
Fig. 7

A. mV MEASUREMENTS

The plus and the minus of the voltage source must be connected on the terminals of the recorder indicated with "+" and "-" with the aid of a two core screened cable (See Fig. 7). If a non-screened measuring cable is used it may cause interference signals on the measuring results. The screening of the measuring cable must generally be connected with the measuring earth terminal indicated with the sign ⊥ (with this terminal the screening of the primary winding of the input transformer of the recorder is connected).

The measuring earth terminal is connected with the instrument earth terminal, indicated with ⊥ in Fig. 7, by means of a hingeable strip.

If the connected voltage source has no voltage with respect to earth, one of the measuring cores can also be connected with the measuring earth terminal (See Fig. 8). If the screening of the measuring cable is earthed at the pick-up, the connection between the instrument earth (⊥) and the measuring earth (⊥) should be broken, thus causing double earthing. If the voltage source is on earth level the plus or the minus of the voltage source can be connected to the screening (at the pick up, fig. 9)



Note: As mentioned in the technical data the internal resistance of the voltage source to be connected may not be more than 5 kΩ per mV of measuring range for the first four positions 1-2-5 and 10 mV.

With measuring range 5 mV, for example, the internal resistance may be 25 kΩ at most. Higher internal resistance gives a consequent longer balancing time.

In the positions 20-50-100 and 200 mV of the switch "SPAN" the input impedance of the recorder is 100 kΩ; curve I in the graph below indicates for these positions the connection between $\frac{\text{recorded voltage V}}{\text{EMF E (of the source)}} \times 100\ \%$ and the internal resistance of the source (the recorded voltage V is equal to the terminal voltage of the source).

In the positions 0.5 to 100 V of the switch "SPAN" the input impedance is 1 MΩ; for these positions curve II indicates the connection between $\frac{\text{recorded voltage V}}{\text{EMF E (of the source)}} \times 100\ \%$ and the internal resistance of the source (the recorded voltage is equal to the terminal voltage of the source).

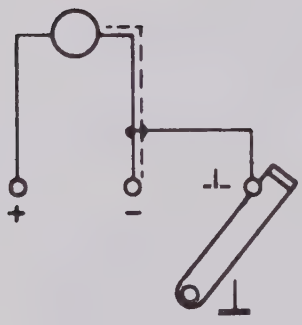


Fig. 8

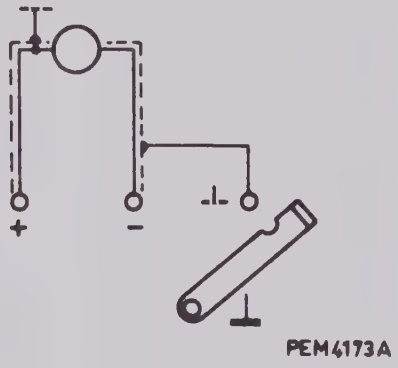


Fig. 9

B. TEMPERATURE MEASUREMENTS

These measurements must be carried out with thermocouples. The following cases must therefore be divided.

- cold junction on 0°C or another constant temperature
- cold junction at room temperature

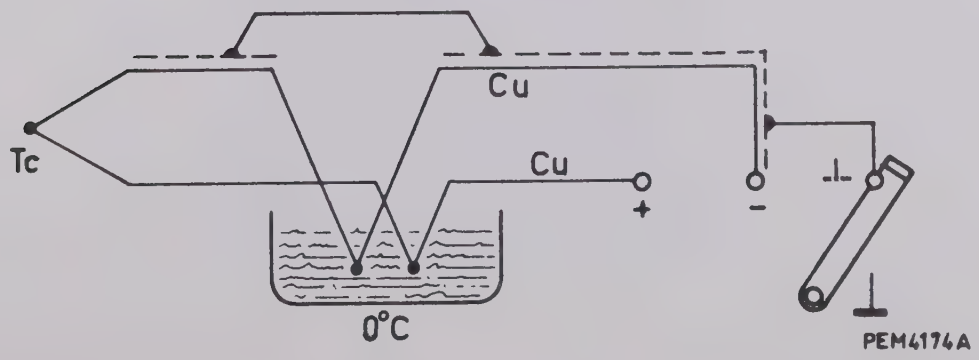


Fig. 10

In the first situation the thermocouple (whether extended with compensation cable or not as yet) should be connected with copper cores on the recorder by means of a screened cord, as indicated in the diagram of Fig. 10; the cold junction can be kept in a container with melting ice or in a container having another constant temperature. For the connection of the screening of the measuring cord the same applies as mentioned under A. mV Measurements.
The temperature to be measured is determined by the indication in mV to be calculated in ^{o}C (with the aid of the temperature/mV table of the used thermocouple) and the temperature of the cold junction to be thus counted. In the second case the thermocouple (whether extended with the compensation cable as yet or not) can be connected as follows:
- directly on the input terminals; the cold junction is then in the recorder
- via a screened measuring cord with copper cores on the input terminals; the cold junction is then outside the recorder.

The temperature of the object is determined by the indication in mV to be calculated in ^{o}C and thus the room temperature (at which the cold junction is practically) to be counted.

Note: If a compensation cable is used it is necessary to take care that the correct cores of thermocouple and compensation cable are connected together.

C. CURRENT MEASUREMENTS

To measure currents with the PM 8100 recorder, they should be converted into voltages which can be measured by the recorder.
If it is required to record the current of an instrument with a current output, this output should be blocked with a resistance as small as possible. If it is desired to keep the resistance as small as possible, the smallest measuring range of the recorder should be chosen (1 mV). If it is required to have full-scale deflection on the recorder with maximum current, the resistance can be calculated with Ohm's Law. If we take the example: $I_{max} = 1$ mA, then $R = 1_{\Omega}$ for 1 mV full-scale deflection.
If the current in a circuit must be measured, this current will run through a load. In most cases the PM 8100 can be directly connected on the load. The span to be adjusted can be calculated with Ohm's Law from I_{max} and the load (R).
When the span is being calculated and results in a value which does not occur on the recorder, the following lower value is adjusted and the potentiometer "SPAN" is adjusted with maximum current so that the recording takes place at the end of the scale.
If the calculated span is too large there are two possibilities of solving this:
- connect resistor in series with the load.
- divide the load

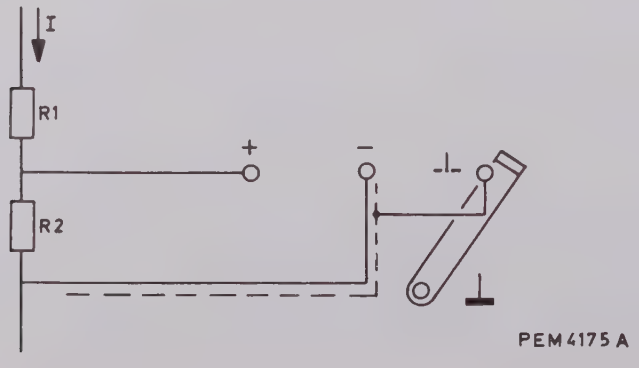


Fig. 11

If a resistor is connected in series with the load it must be chosen as small as possible so as to influence the current minimally.
The recorder is connected on the series resistor and adjusted on the smallest measuring range. The series resistor is calculated from the maximal current (I_{max}) and the span (1 mV). If the current should not be influenced at all, the load (R) should be split into R_1 and R_2 (See Fig. 11). For calculating the resistors : $R_1 + R_2 = R$ and R_2 is calculated as the series resistor.
The recorder is connected on resistor R_2 and adjusted on 1 mV.

D. ACCESSORIES

1. Event marker type PM 9802

The unit (Fig. 12, item 1) is equipped with two contact pins with which it is fixed in the relevant contact sockets of the recorder (item 2). The external switch with which the unit must be operated should make an interconnection between sockets BU11 and BU12 (See Fig. 13). The ink cartridge is mounted as described in chapter V-D.

2. Slave potentiometer type PM 9803

The supply voltage for the potentiometer is connected on sockets BU13 (begin) and BU15 (end) and the slave voltage can be taken from terminals BU13 and BU14 (slider), see Fig. 13 and Fig. 14.

Note: It must be remembered that the slide contact of the slave potentiometer cannot cover the entire wound part of the potentiometer; the begin resistor R1 is approx. 20 Ω on delivery.
The above means that when the pointer is on the begin point of the scale there is a resistance of approx. 20 Ω between the terminals BU13 and BU14. If necessary, this begin resistance can be compensated by incorporating the slave potentiometer in a bridge circuit according to the diagram below (Fig. 15).

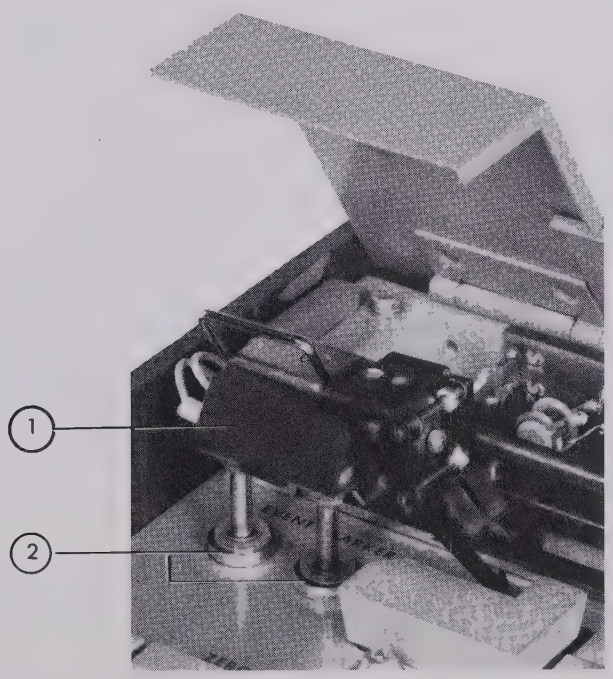


Fig. 12

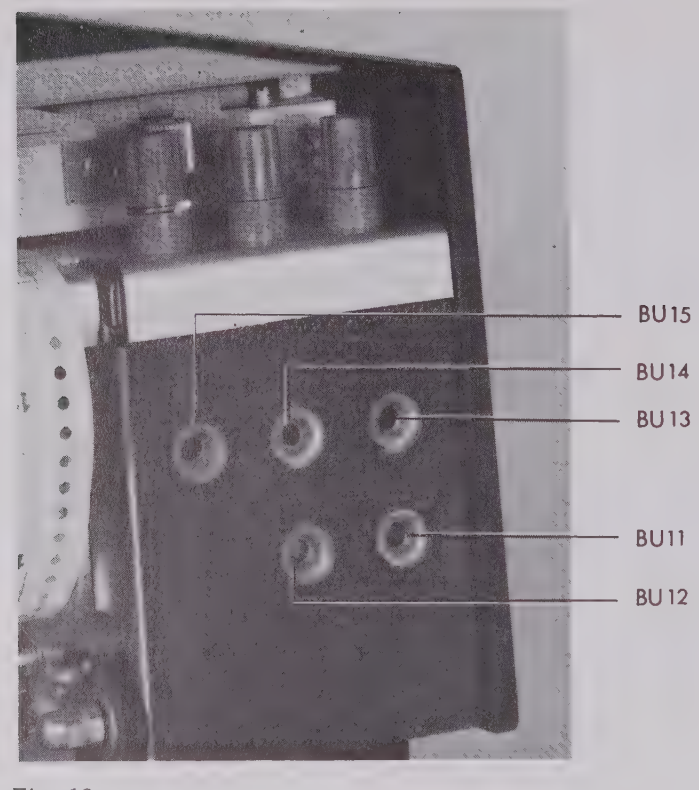


Fig. 13

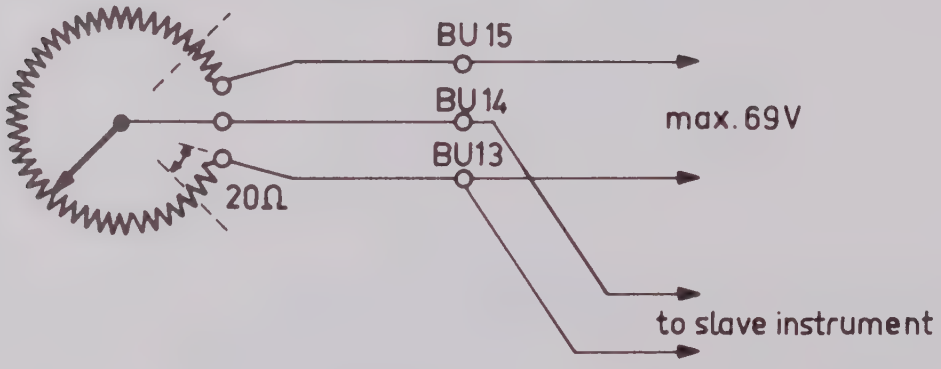
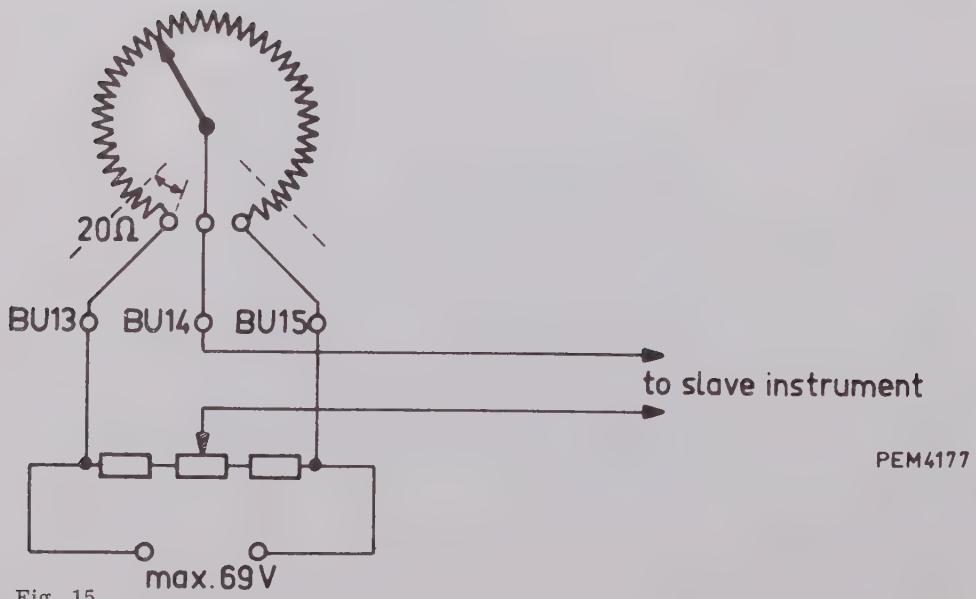


Fig. 14

PEM4176



PEM4177

Fig. 15

E. MAINS VOLTAGE AND EARTHING

The recorder must be connected on a wall receptacle with rim earthing via the mains cable which is provided with a universal plug with rim earthing.

220 V

To connect the instrument on 220 V, the switch (Fig. 16, item 1) must be in position 220 V which can be seen in the window (item 2).
In this position of the switch a fuse (item 3) of 200 mA delayed action must be provided.

110 V

The instrument can be connected on 110 V by turning screw (item 1) one turn loose and shifting the switch. The indication 110 V is then visible in the window (item 2). A fuse (item 3) of 400 mA delayed action must then be used.

245 V

If the instrument must be connected on 245 V, the switch (item 1) must be in position 220 V and a fuse (item 3) of 200 mA delayed action must be used. The connection which runs from BU4/J to the supply transformer (T5) point 4 must be led to point 15 of T5 (see circuit diagram Fig. 54).

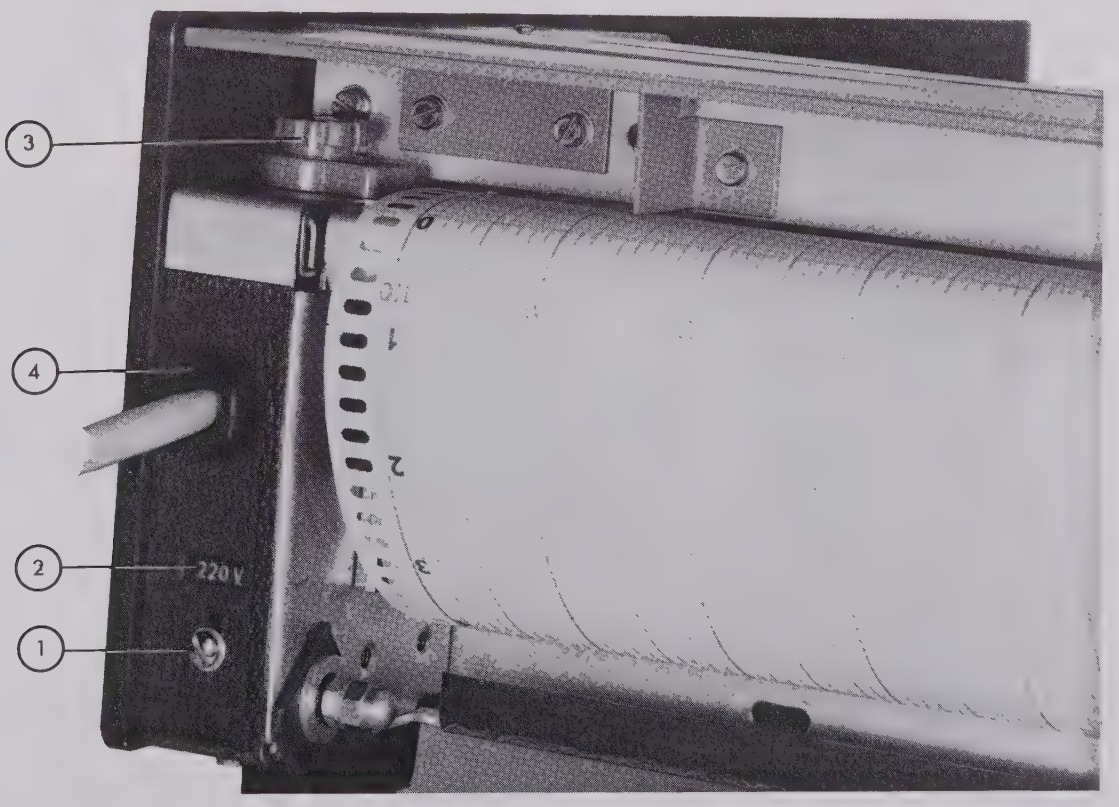


Fig. 16

V. PUTTING INTO OPERATION

A. SWITCHING THE MAINS VOLTAGE ON AND OFF

By depressing the pushbutton "POWER ON" the recorder is switched on (See Fig. 17); the control lamp in the pushbutton is then on.
It is switched off by depressing this button once again.

B. STAND BY

By pressing the button "STAND BY" (see Fig. 17) only the servomotor is switched off. This pushbutton can be used when no measurements are carried out whereas the recorder must still be ready for immediate use (no warming-up time for the amplifier). Also in the case where the transducer circuit is interrupted can the pushbutton be pressed so that the adjusting power on the pointer dwindles.
To adjust the amplification this pushbutton should also be used.
See under point F. of this chapter.

C. RECORDING CHART

1. Mounting the recording chart

- Remove the packing from the roll of chart, hold the roll with the round perforations upwards and mount the supply roller according to Fig. 18. Press the roll of chart firmly against the flange of the supply roller and ensure that the edges of the chart remain flat.

Note: The roll of recording chart delivered with the recorder has already been mounted on the supply roller.

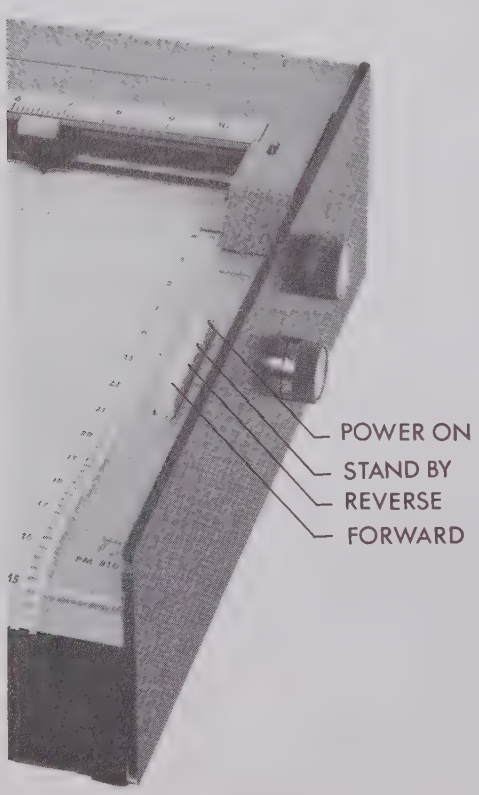


Fig. 17

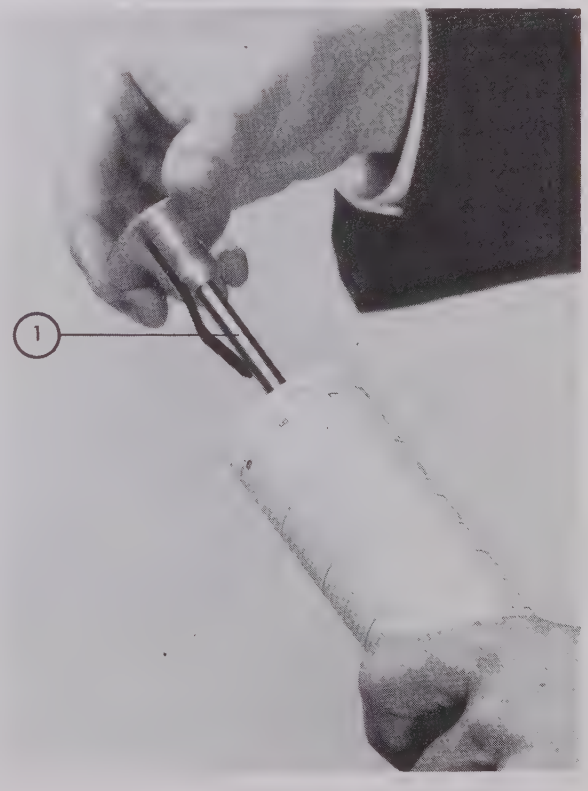


Fig. 18

- Slide button "PEN" out of position "DOWN".
- Open the protective cover (Fig. 19 item 1)
- Pull up the guiding devices (Fig. 19, item 2)
- Place the supply roller with recording chart between the springs (Fig. 20, item 1) in the supply container; slide the chart under the measuring potentiometer, the pen lift strip and the tearing string.
- Lead the chart across the sprockets in such a way that the edges run parallel with the sides of the instrument.
- Press the guiding devices downwards and check the working of the chart transport by turning knob (Fig. 19, item 3).

2. Chart transport

By pressing the pushbutton "FORWARD" (Fig. 17) the chart is transported forwards and if the pushbutton is again pressed the chart transport stops. The pushbutton "REVERSE" (Fig. 17) can then be pressed so that the chart is transported backwards.
The desired chart speed can be adjusted with knob (Fig. 19, item 4)

3. Adjusting on desired hour line

The recording can be adjusted on the desired hour line of the recording chart by turning knob (Fig. 19, item 3).

4. Tearing off recording chart

The recording chart can be torn off along the string (Fig. 19, item 5)

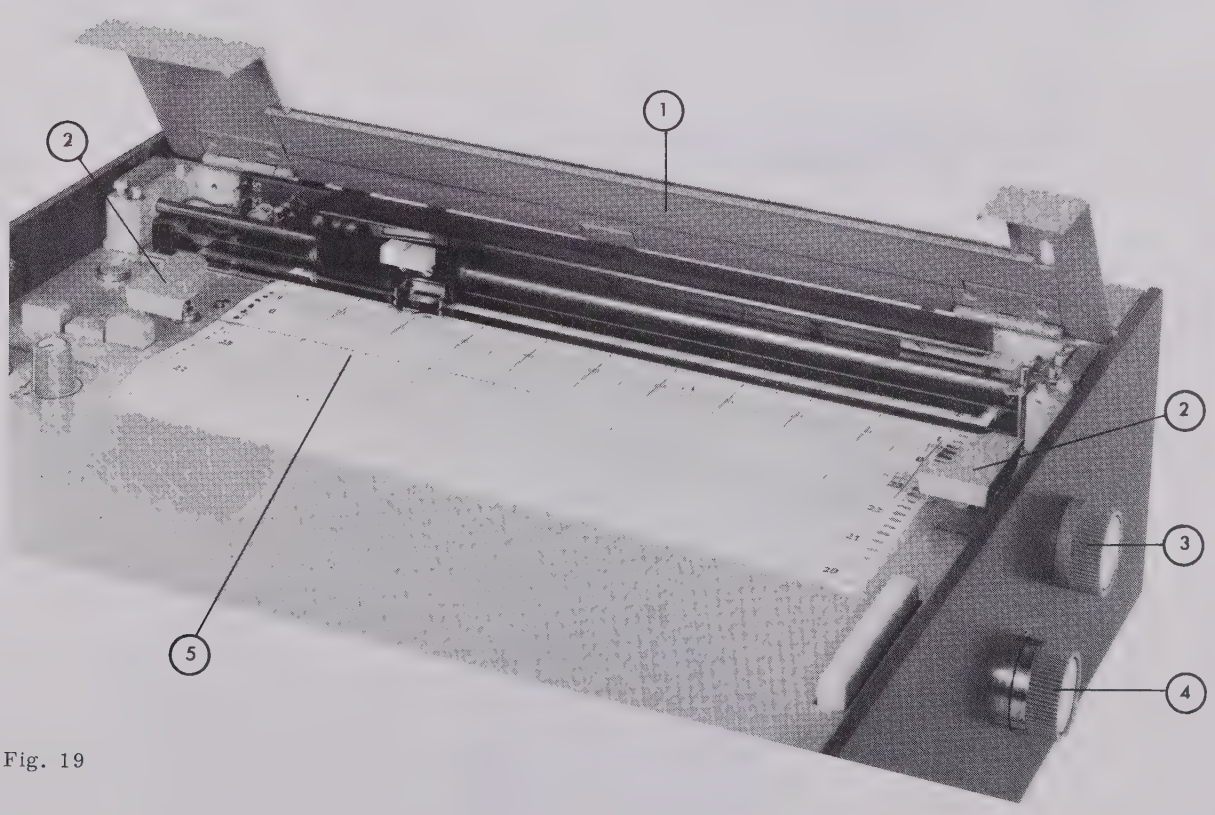


Fig. 19

D. INK CARTRIDGE

- Take an ink cartridge with the required colour from the delivered kit and remove the capsule mounted around the writing pen of the cartridge (Fig. 21, item 1); also remove the sealing from the opening, item 2.
- Slide knob "PEN" out of position "DOWN".
- Put the cartridge in the holder (Fig. 22, item 1); first slide the flat part of the cartridge under the two springs, item 2 and then push the cartridge further into the holder. The ink cartridge can be taken out by pressing the strip, item 3, of the holder downwards.
- The writing pen can be lifted from the chart by sliding knob "PEN" out of position "DOWN".
- If the recorder is not used for some time, it may occur that the ink supply is blocked; then take the ink cartridge out of the holder, put the bellows (in the service kit) in the opening at the top of the cartridge and squeeze the bellows several times until writing pen is moist again.

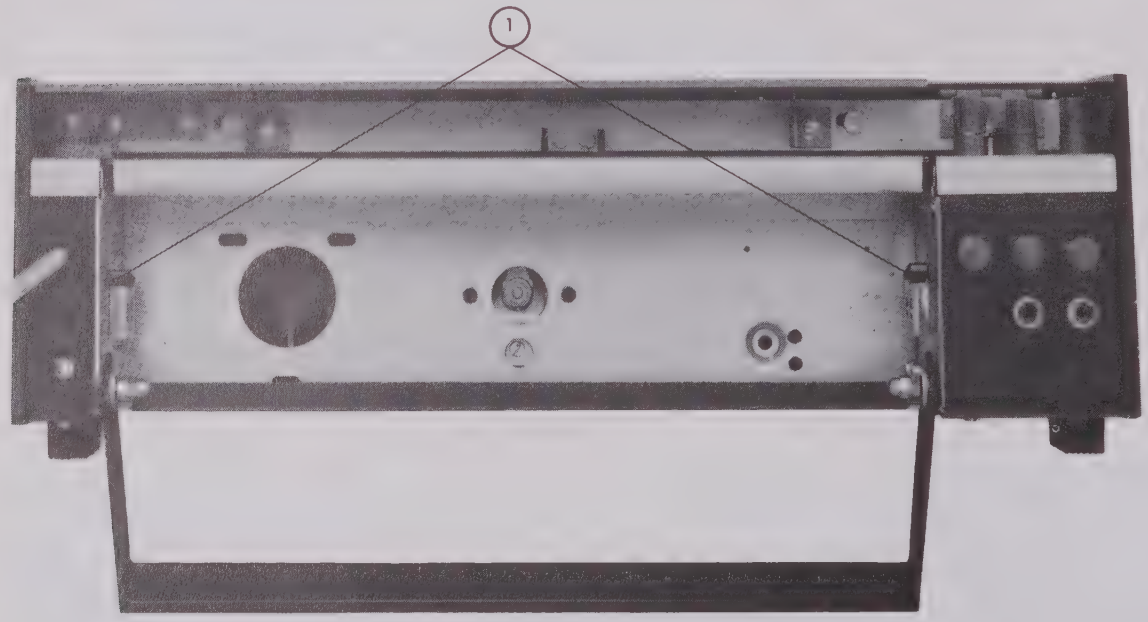


Fig. 20

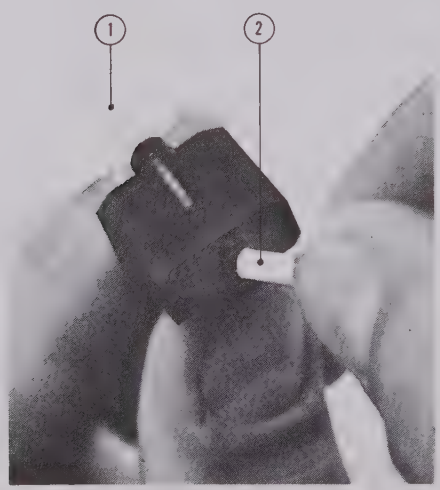


Fig. 21

E. MEASURING RANGES (See Fig. 23)

The recorder has sixteen measuring ranges, the span and zero point of which can be chosen separately.

The span can be adjusted with the aid of switch "SPAN", item 1, on 1-2-5-10-20-50-100-200-500 mV and 1-2-5-10-20-50-100 V.

The span of the chosen measuring range coincides with the full-scale deflection when potentiometer "SPAN", item 2, is in position "CAL".

If the potentiometer is put in the range "VAR", the span of the chosen measuring range can be increased max. a facotr 2.5 to 3 (potentiometer turned fully clockwise). This is valid for positions 20 mV to 100 V of the switch "SPAN". The zero point can be set on -100 %, 0 %, or +100 % by means of pushbutton "ZERO", item 3. The given percentages concern full-scale deflection if potentiometer "ZERO", item 4, is in position "CAL". With potentiometer "ZERO" in the range "VAR", the zero point can be set between -10 % and +65 % if the -100 % pushbutton is pressed. If the pushbutton +100 % is pressed, the zero point can be set between +40 % and +115 % with the aid of potentiometer "ZERO".

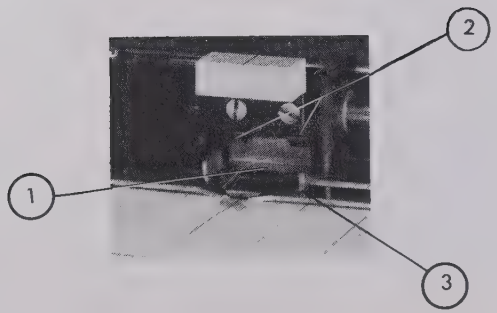


Fig. 22

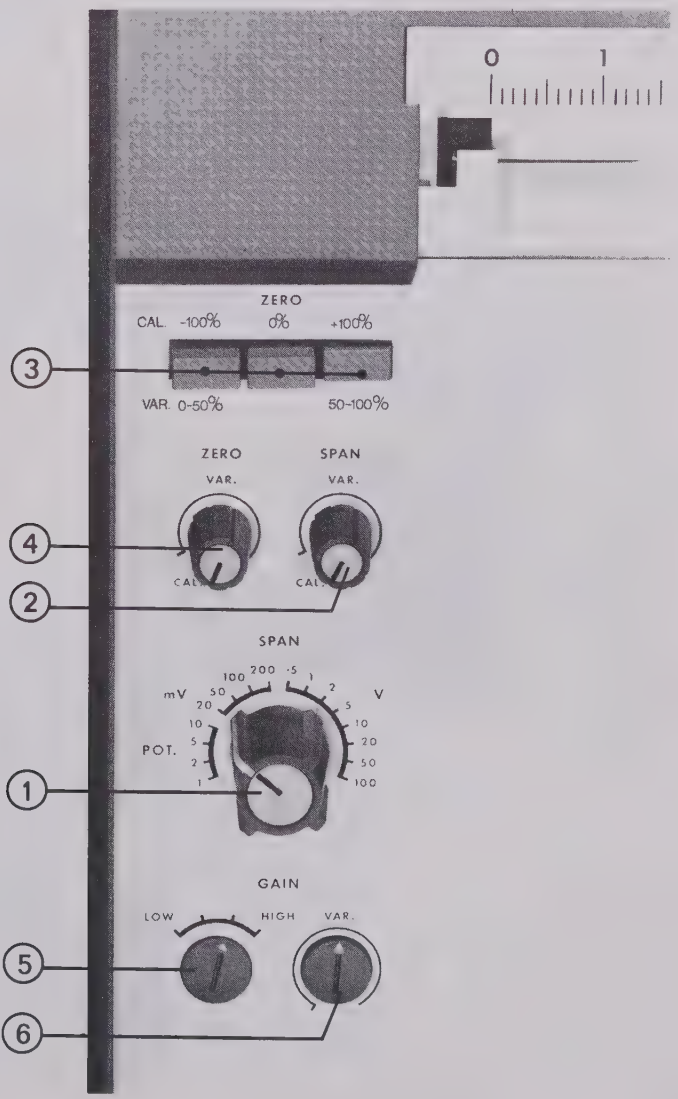


Fig. 23

F. ADJUSTING THE AMPLIFICATION

Note: The amplification only need be adjusted for the first four positions (1-2-5 and 10 mV) of the selector switch "SPAN" (Fig. 23, item 1). For the remaining positions (20 mV and higher) the amplification has already been properly adjusted on delivery, which is possible because in these positions the adjustment of the amplification does not depend on the source impedance. If it is desired to change the adjustment of the amplification in the above named positions, however, this can be done with potentiometer "GAIN" at the rear side of the recorder (See Fig. 24).

The following adjusting instructions are valid, therefore, only for the first four positions of switch "SPAN".

- Connect replacement resistor of the transducer on input terminals ("+" and "-").
- Put switch "SPAN" in one of the first positions and set the pointer approx. in the middle of the scale with the aid of the "ZERO" adjustment.
- Then adjust the amplification so that the measuring carriage does not oscillate; for this, turn switch "GAIN" (Fig. 23, item 5) fully clockwise and turn potentiometer "GAIN" (Fig. 23, item 6) sufficiently far counter-clockwise.
- Press pushbutton "STAND BY" and shift the pointer manually to the left.
- Press button "STAND BY" once again, so that the pointer is again moved into the middle of the scale; the movement must be critically damped, i.e. with an overshoot of max. 1 scale division.
- If the measuring carriage overshoots the balanced position too far, then turn potentiometer "GAIN" (fig. 23) still further counter clockwise; if the measuring carriage creeps towards balanced position, then turn potentiometer "GAIN" a little clockwise.

"GAIN" is turned alsmost fully counter-clockwise, switch "GAIN" must be turned so many steps counter-clockwise until the returning movement can be critically damped with the potentiometer without it having to be turned fully or almost fully counter-clockwise.

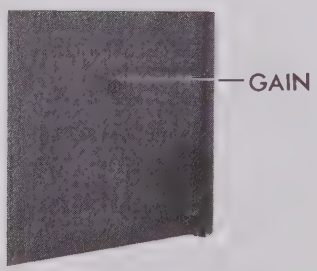


Fig. 24

IV. MAINTENANCE

The maintenance operations given below should be carried out in theory once every six months. In the case of intensive use or under unfavourable operating conditions this may have to be done more often.

A. MEASURING POTENTIOMETER (Fig. 25)

- The potentiometer can be cleaned after the protective cover (Fig. 25, item 1) has been opened.
- The windings (Fig. 25, item 2) should then be cleaned with the brush from the service kit.
- THE MEASURING POTENTIOMETER MUST NEVER BE LUBRICATED WITH OIL

B. MECHANICAL PARTS

The parts mentioned below should be lightly lubricated with the oil supplied.

- The guide spindle of the measuring carriage (Fig. 25, item 3)
- The spindles of the guide wheels (Fig. 26, item 1)
- The spindle (Fig. 26, item 2) at both sides of bearings (item 3)
- The gear wheels

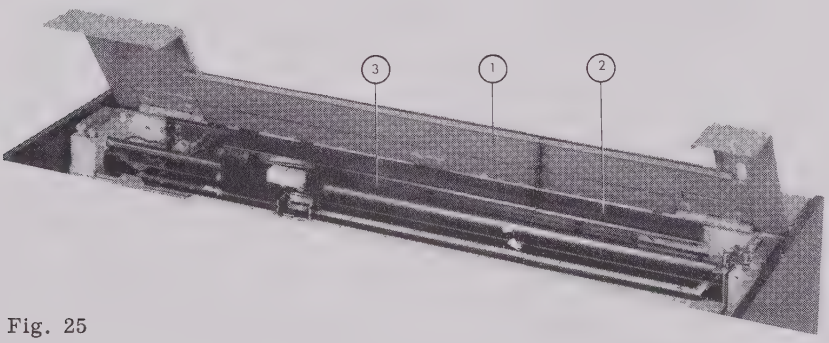


Fig. 25

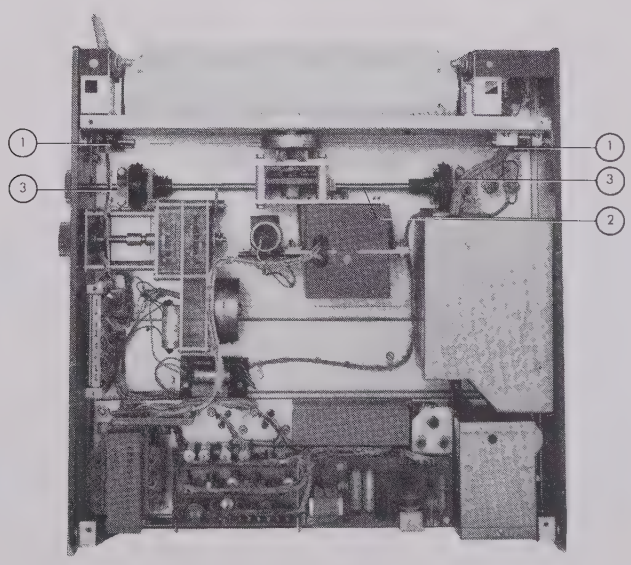


Fig. 26

VII. OPERATING PRINCIPLE

A. PRINCIPLE OF AUTOMATIC COMPENSATION

In the case of these measurements the unknown voltage is compensated by means of a servo-mechanism (See Fig. 27).

The unknown voltage is connected in series with the diagonal of the measuring bridge. The bridge is supplied on points C and D with a stabilised d.c. current of known size. There thus exists a known voltage between points A and B, i.e. E_c, with which the unknown voltage E_x is connected in series and is opposite. The difference voltage E_c-E_x is converted into an a.c. voltage by chopper T and is added to the amplifier V. The output voltage of the amplifier drives the servomotor M. The servomotor is mechanically coupled with the slider of the measuring potentiometer R_m. The slider contact is then shifted until the difference voltage E_c-E_x has become zero.

The pointer which is also coupled with the slider of the measuring potentiometer indicates the value of the voltage E_x.

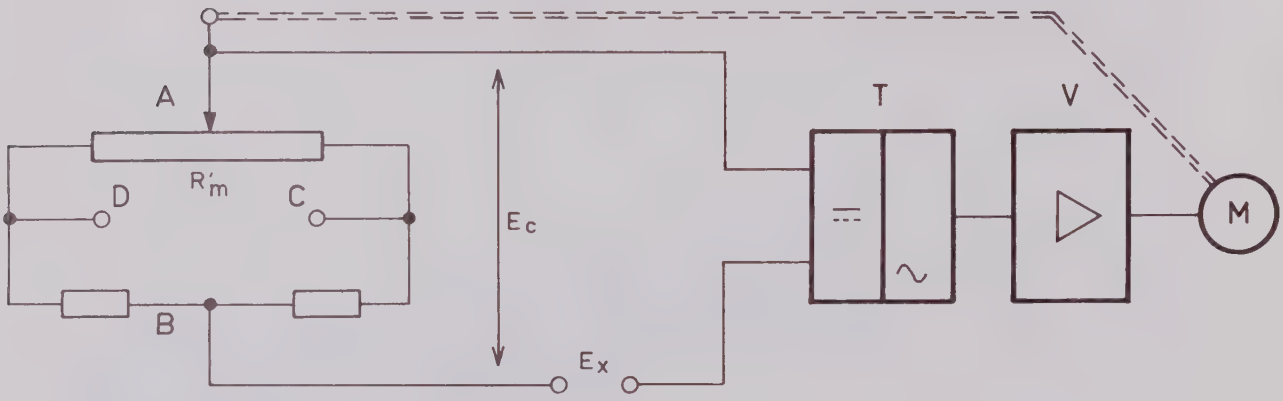


Fig. 27

MA5197

B. THE RECORDER (Fig. 53 and 54)

The d.c. voltage to be measured is connected on terminals "+" and "-". This voltage is, depending on the value, supplied to the measuring bridge in three ways:

1. Voltages of 1-2-5 and 10 mV
   These voltages are connected directly in series with the diagonal of the measuring bridge which is formed by the measuring potentiometer and the measuring range. The measuring bridge is supplied with a constant current of 1 mA on points BU3/E and BU3/F. The signal of the measuring bridge is added to the amplifier which is composed of various parts (see hereafter).
2. Voltages of 20-50-100 and 200 mV.
   These voltages are reduced to a voltage of 1 mV by an attenuator with a value of 100 kΩ and this voltage is then further processed as under 1.

3. Voltages of 0.5-1-2-5-10-20-50 and 100 V.
   These voltages are reduced to a voltage of 10 mV by an attenuator with a value of 1 MΩ and this voltage is then further processed as under 1.

Starting from the signal which is supplied to the amplifier (See point 1) it first passes a hum filter which ensures that the influence of possible interference voltages on the measuring signal are brought below the permissible values.
The (d.c. voltage) signal is then converted into an a.c. voltage signal which is added to the input transformer (symmetrical input) by a chopper.
As from the secondary side of this transformer the signal is supplied to the input amplifier via an adjustable attenuator circuit "GAIN".
On the output of this amplifier unit there are two potentiometers ("GAIN") as regards the adjustment of the amplification on the compensation positions (see point 1) and the attenuator positions (see point 2 and 3).
One of these potentiometers works in combination with switch "GAIN".
The output amplifier drives the servomotor with which the slide contact of the measuring potentiometer is coupled; this contact is slid until the input voltage at the amplifier has become zero.
The pointer which is coupled with the slide contact indicates the value of the voltage to be measured.
The diagram shows further the working of the pushbutton switches.

VIII. TROUBLESHOOTING

By means of the list below the user can correct simple interferences himself so as to prevent loss in time.

To localise interferences it must first be checked:

- if there is a mains voltage
- the transducer circuit must be removed.
- the input terminals ("+" and "-") and the measuring earth (⊥) must be interconnected with the instrument earth (⊥).

Problem	Possible causes	Cure
Instrument does not work and LA1 (power on) is not on	fuse VL3 mains cable	Measure mains cable and VL3 and replace where necessary
LA1 is on, instrument does not work	fuses VL1, VL2, VL4	Measure VL1, VL2 and VL4 and eventually replace
No power on measuring carriage	cord transmission defect STAND BY button pressed	Check cord fastening
When shifting measuring carriage it experiences a resistance although it does not return to its start point	Chopper Measuring bridge current zero Amplifier Input unit Motor part of servosystem	Replace chopper measuring bridge supply chapter X Amplifier, chapter IX Input unit, chapter XI Motor windings
Dead band	GAIN adjustment Too much friction in the drive mechanism	Adjust GAIN according to chapter V-F. Check all mechanical transmissions
Irregular indication	Measuring potentiometer dirty Chopper	Clean measuring potentiometer see chapter VI Replace chopper
Irregular writing	Ink cartridge empty Recording chart wet Pen lifting device distorted	Replace ink cartridge Replace chart
Recording chart askew	Suspension of supply roller	Mount supply roller between springs
Irregular chart speed	Slip coupling on the sprocket shaft Fixing gear wheels on gear box	Replace sprocket shaft, chap. XVI Fix gear wheels

IX. AMPLIFIER CHECK

A. GENERAL VOLTAGE MEASUREMENTS

The voltages below can be measured on the indicated points with a d.c. voltage valve voltmeter and an a.c. voltage valve voltmeter resp. The operations below should also be carried out.

- Place SK4 ("SPAN") in position 1 mV
- Short-circuit terminals "+" and "-"
- Turn SK2 and R30 ("GAIN") fully clockwise

1. Supply voltages

Unit D/5	Instr. earth ⊥	4 - 6 V d.c.
Unit D/4	Instr. earth ⊥	14 - 17 V d.c.
Unit D/3	Instr. earth ⊥	22 - 28 V d.c.
Unit F/3	Unit F/6	10 - 13 V d.c.

If the above d.c. voltages are exactly required the a.c. voltages do not generally have to be measured.

T5/1	T5/2	ca. 50 V a.c.
T5/2	T5/3	ca. 60 V a.c.
T5/3	T5/4	ca. 110 V a.c.
T5/4	T5/15	ca. 25 V a.c.
T5/6	T5/7	ca. 16 V a.c.
T5/8	T5/9	ca. 25 V a.c.
T5/16 (or Unit E/8)	T5/17 (or Unit E/9)	ca. 17 V a.c.
T5/18 (or Unit K/4)	T5/19 (or Unit K/5)	ca. 33 V a.c.
T5/12	T5/14	ca. 6.5 V a.c.

2. Ripple voltages

Unit D/5	Instr. earth ⊥	$\leq$ 0.1 mV a.c.
Unit D/4	Instr. earth ⊥	$\leq$ 0.3 mV a.c.
Unit D/3	Instr. earth ⊥	$\leq$ 40 mV a.c.
BU3/E	BU3/F	$\leq$ 0.5 mV a.c.

3. Collector emitter voltages ($-V_{ce}$)

TS1	0.5 - 1.5 V d.c.
TS2	1.2 - 2.2 V d.c.
TS3	3 - 4 V d.c.
TS4	11 - 14 V d.c.
TS5	4 - 6 V d.c.
TS6	5 - 7 V d.c.
TS7	3 - 5 V d.c.
TS8	8 - 11 V d.c.

4. Voltages across collector and emitter resistors resp. ($V_{Rc} - V_{Re}$)

Note: From these voltage measurements the collector and emitter currents resp. can be calculated, if required.

TS1	R7 (180 kΩ)	3 - 5 V d.c.
TS2	R8 (56 kΩ)	2.5 - 4 V d.c.
TS4	R9 (100 Ω)	0.1 - 0.15 V d.c.
TS5	R19 (22 kΩ)	4 - 6 V d.c.
TS6	R20 (10 kΩ)	8 - 10 V d.c.
TS7	R26 (10 kΩ)	10 - 12 V d.c.
TS8	R27 (1.2 kΩ)	14 - 16 V d.c.
TS9	R28 (12 Ω)	0.1 - 0.15 V d.c.
TS10	R29 (1 kΩ)	11 - 13 V d.c.

B. INSULATION RESISTANCE

To measure the insulationresistance the recorder must be disconnected from the mains. The insulationmeter with which the measurement is carried out may give maximal a voltage of 50 V. The short-circuit strip between terminals BU7 (⊥) and BU8 (⊥) must be removed. The insulation resistance can then be measured between the points below.

BU7	BU8	≥ 6000 MΩ
BU3/E	BU8	≥ 6000 MΩ
BU3/B	BU8	≥ 6000 MΩ

C. DYNAMIC MEASUREMENTS

1. Interference signals

The interference signals are measured under the following conditions
- Place switch SK4 ("SPAN") in the position 1 mV
- Short-circuit terminals "+" and "-"
- Turn SK2 and R30 ("GAIN") maximal clockwise

Unit C/7	Instr. earth ⊥	≤ 1.5 mV
+ C14	Instr. earth ⊥	≤ 40 mV
Unit C/2	Instr. earth ⊥	≤ 0.5 V
Collector TS9	Collector TS10	≤ 2 V

2. Amplification and phase

- Short-circuit input terminals ("+" and "-")
- Put SK4 ("SPAN") in the position 1 mV
- Press pushbutton "STAND BY"

Then move the measuring carriage out of its zero point until the voltage on the input of the amplifier (BU3/B and BU3/C) is 0.1 mV.
The voltage between the points unit C/7 and instrument earth (⊥) must then be ≥ 60 mV_{eff}.
Slide the measuring carriage until the voltage on the input of the amplifier (BU3/B and BU3/C) is 0.01 mV; the voltage between the "+" terminal of C14 and instrument earth (⊥) must then be ≥ 600 mV_{eff}.
- Press pushbutton "STAND BY" again
- Move the pointer to approximately the centre of the scale, by means of the potentiometer "ZERO"

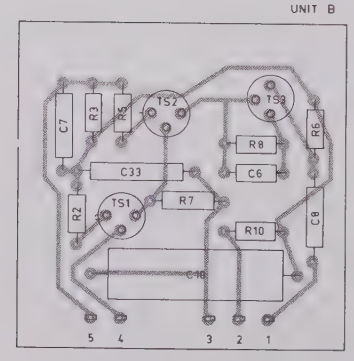
If the input voltage of the amplifier then varies ± 3 μV with respect to the zero point, it will be possible to measure a voltage of 12 V_{eff} between the collectors of TS9 and TS10. This voltage must turn 180° in phase when the polarity of the input voltage varies.
Make BU3/C positive with respect to BU3/B.
The voltage between BU4/5 and BU4/6 must then be in phase with the voltage between BU4/8 and BU4/10; BU4/6 and BU4/10 must then be connected with earth.

Note: The mains voltage must be connected in the exact phase, other wise short-circuiting will occur.

3. Input impedance

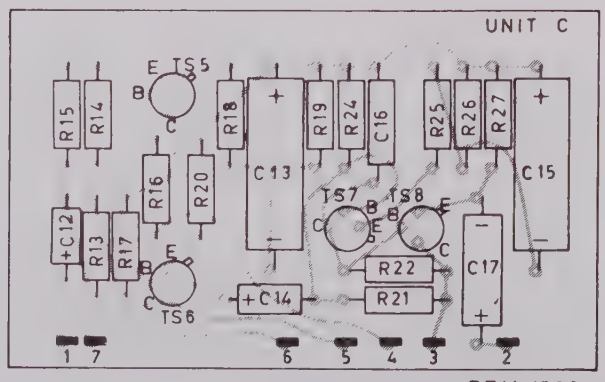
- "STAND BY" button must be pressed in.
- Place the switch "SPAN" (SK4) in the position 1 mV
- Set "ZERO" (SK5) on 0 %
- Turn SK2 and R30 ("GAIN") fully clockwise and short-circuit the input terminals "+" and "-".
- Place the pointer accurately on point 2 of the scale and measure the a.c. voltage on Unit C/7 with respect to the instrument earth (⊥).
- Connect a resistance box between the input terminals "+" and "-" and slide the pointer to point 4 on the scale.
- Adjust the resistance box so that the voltage on Unit C/7 is equal to the previously measured value.
- The adjusted value of the resistance box must be at least 5 kΩ

Description	Fig.	Service code number
AMPLIFIER		
Unit B complete	28	4822 216 90371
Unit C complete	29	4822 216 90136
Unit D complete	30	4822 216 90372
Unit E without R34-R43-R51-GR13-T4-VL2-VL4	31	4822 216 90229
Unit F without C18	32	4822 216 90139
Unit H complete		4822 218 60077
Print unit H with R4-GR1-GR2	33	4822 216 90018
L1, L2 for unit H	54	4822 158 20086
Unit J complete	34	4822 216 90218
T1 input trafo (with wires in screen box)	54	4822 142 40221
T2 isolating trafo	54	4822 142 40211
T3 driver trafor	54	4822 142 40118
Terminal bracket for T3		4822 492 61513
T4 isolating trafo	54	4822 142 40121
Terminal bracket for T4		4822 492 61486
T5 supply trafo	54	4822 146 50146
SK2 "GAIN"	54	4822 273 40214
Knob for SK2		4822 413 30345
R30 potentiometer 22 kΩ 3 W 5 %	54	4822 103 20207
Knob for R30		4822 413 30305
R31 potentiometer 22 kΩ 3 W 5 %	54	4822 103 20175
RE1 chopper	54	4822 280 10037
Foot for chopper		4822 255 70014
C1, C2 elco 4.7 μF, 10 V	54	4822 124 10014
C18 bipolar elco 2x50 μF, 30 V	54	4822 124 40091
C25 mepolesco 1 μF 100 V	54	4822 121 40176
BU4 contact block 10 pens	54	4822 267 50096
Contact plate for BU4	54	4822 216 90296
BU3 contact block 6 pens	54	4822 267 40115
Contact plate for BU3	54	4822 466 10135



ST211

Fig. 28



PEM 4538

Fig. 29

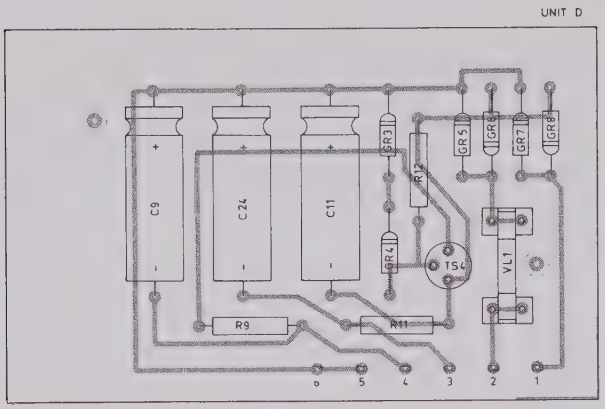


Fig. 30

ST212

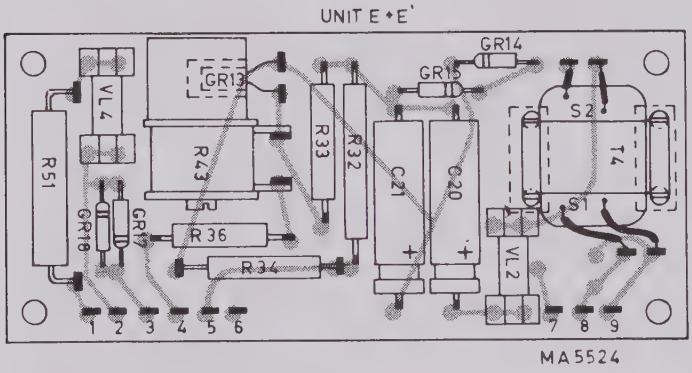


Fig. 31

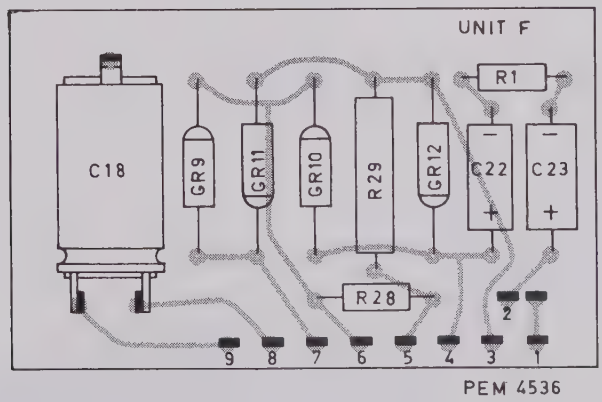


Fig. 32

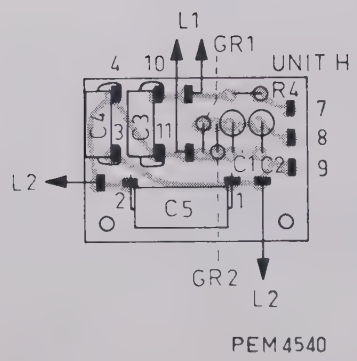


Fig. 33

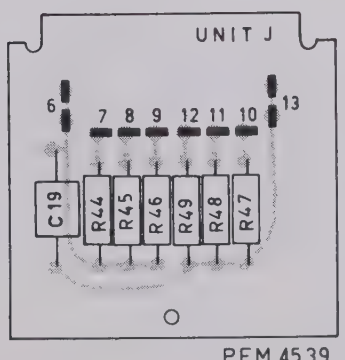


Fig. 34

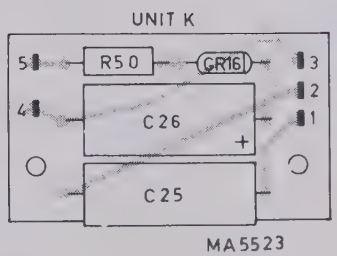


Fig. 35

X. MEASURING BRIDGE CURRENT CHECK

A compensator which must be set exactly on 50 mV is required for checking the measuring bridge current.

Connect the compensator on the terminals BU1 and BU2 of the amplifier (Fig. 36, item 1) and check whether there is a voltage of 50 mV $\pm$ 0.1 %. The voltage must be adjusted with R39 (Fig. 36, item 2), and the voltage should be constant on all positions of the switch "SPAN" (SK4).

If the measuring bridge current deviates on one of the positions of SK4 the following resistors must be checked.

R139 for: 1 mV - 2 mV - 20 mV - 50 mV - 100 mV and 200 mV

R137 for: 10 mV - 500 mV - 1V - 2 V - 5 V - 10 V - 20 V - 50 V and 100 V

R138 for : 5 mV

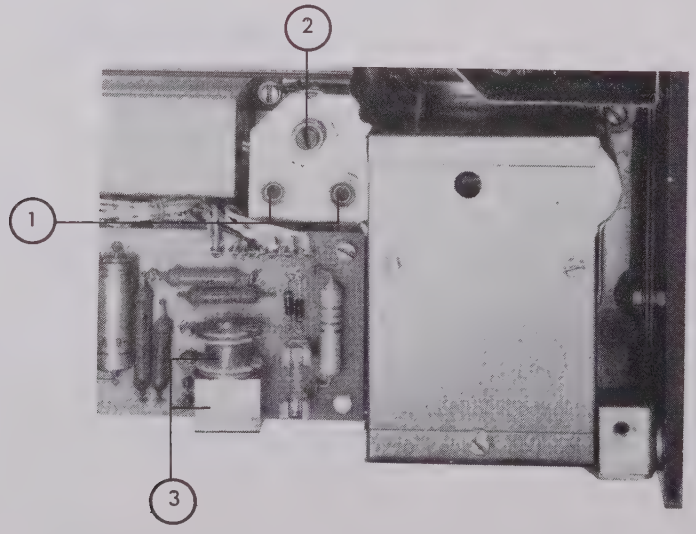
The stability of the measuring bridge current must be better than 0.05 % (of 50 mV) with mains voltage variations of $\pm$ 10 %; if this is not the case, the resistor R34 must be adapted as follows:

- Replace R34 by a resistance box and adjust it so that the voltage on BU1 and BU2 varies as little as possible with a mains voltage variation of $\pm$10 %. It may be necessary to adjust the voltage on BU1 and BU2 during the adjusting procedure.
- Replace the resistance box by a resistor from the E24 series which approximates the set value as closely as possible.
- Check once more the voltage on BU1 and BU2.

Voltages:

T4/3	T4/4	6 - 8.5 V a.c.
Across C20		6 - 8.5 V d.c.
Across C21		12 - 17 V d.c.

Description	Fig.	Service code number
R37 block resistance 50 Ω, 0.1 %	54	4822 114 10072
R43 + GR13 zener diode assy	36 - 3	4822 130 30007
R39 potentiometer 3.3 kΩ, 3 W, 5 %	36 - 2	4822 103 20052



XI. INPUT UNIT CHECK

Before the input unit is checked the following should be ensured:
- the amplifier functions properly, see chapter IX
- the measuring bridge current is adjusted according to chapter X

A. DAMPING

The damping must be adjusted according to chapter V-F.
If the damping is not critical in one of the positions 2-5-10 mV R150-R151-R152 resp. must be checked.
If the damping on one of the positions 20 mV to 100 V is not critical the resistor from the series R141 to R149 and R153 as regards the deviating position must be checked.

B. ZERO POINTS (-100 %, 0 %, +100 %)

To check the accuracy of the zero points, the points below must be applied.
- Place SK4 ("SPAN") in the position 1 mV
- Press 0 % button of SK5 ("ZERO")
- Place SK6 ("ZERO") in the position "cal"
- Short-circuit the input terminals "+" and "-" (BU5 and BU6)

The recording must take place on the zero line of the chart and correspond with the zero point on the scale. When this is not the case, it should be adjusted by sliding the measuring potentiometer and adjusting the pointer. The adjustment goes as follows:
- Loosen screws (Fig. 37, item 1) one turn
- Open protective cover or take it from the instrument by loosening screws (Fig. 37, item 2)

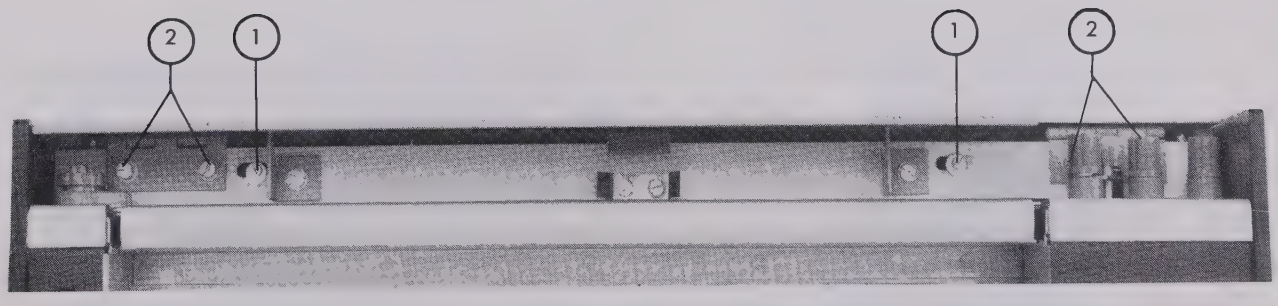


Fig. 37

- Then turn the knurled screw (fig. 38, item 1) until the recording takes place on the zero line of the chart.
- Tighten screws (Fig. 37, item 1) and recheck the recording.
- Close the protective cover and loosen the screws (Fig. 39, item 1) one turn.
- The pointer must be shifted so that the indication corresponds to the zero point on the scale; both screws must be then retightened.

The zero point +100 % is checked by pushing the button 100 % of the switch "ZERO". The pointer should now be on the end of the scale, the permissible tolerance is ± 0.6 mm.

The zero point -100 % may be checked as follows:

- Put the switch "ZERO" in the 0 % position.
- Connect an adjustable DC voltage to the recorder input terminals and adjust the voltage until the pointer is exactly on the end of the scale.
- Now push the button -100 %, the pointer has to be on the zero point of the scale. Also in this case the permissible tolerance is ± 0.6 mm.

Then set an arbitrary zero point and note this exactly. Check whether the deviation with respect to the noted zero point is not more than ± 0.5 mm on all positions of SK4 ("SPAN").

With deviations greather than the permissible tolerance, the measuring potentiometer must be checked for its linearity and the resistors R123 to R128 (Unit M) for their ohmic value.

C. POSITIONS SK4 ("SPAN")

Connect a compensator on terminals "+" and "-" (BU5 and BU6). The switch SK7 ("SPAN") should be put in the position "cal" and the positions 1 mV to 100 V should be checked on the scale. The max. deviation may be ± 0.6 mm.

If one of the compensator positions (1-2-5-10 mV) deviates, the resistors R119 to R122 (Unit M) should be checked.

If one of the attenuator positions 20 mV to 200 mV or 500 mV to 100 V deviates, the 100 kΩ and the 1 MΩ attenuator resp. (Unit M) must be checked.

D. DISASSEMBLY

Remove the base plate from the recorder. Remove the two screws from the screening can of the input unit and remove the screening can from the unit.

When the input unit is to be removed from the recorder, first detach knobs SK4 ("SPAN"), SK6 ("ZERO") and SK7 ("SPAN"). Remove the three screws at the bottom of the input and pull the contact plate of the cable form out of the contact block. The input unit can now be placed beside the recorder. If required, unsolder points S1, S2, S3 of the measuring potentiometer and the wires connected to terminals "+", "-" and "⊥ ", so that the input unit can be removed completely.

Fig. 38

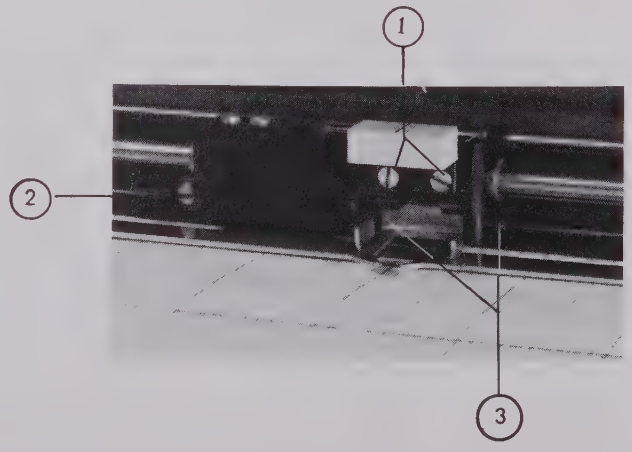


Fig. 39

INPUT UNIT

Description				Fig.	Service code number
SK4 "SPAN" (16 positions)				54	4822 273 80124
Knob for SK4					4822 413 40112
Lid for knob SK4					4822 413 70037
SK5 (-100 %, 0 %, +100 %)				54	4822 276 30151
SK6 "ZERO"				54	4822 271 30142
R132 potentiometer "ZERO"				54	4822 103 20208
Knob for SK6				54	4822 413 30082
Lid for knob SK6					4822 413 70038
SK7-R101-R104 potentiometer + switch "SPAN"				54	4822 101 40042
Knob for SK7					4822 413 30083
Lid for knob SK7					4822 413 70038
Unit M complete				40	4822 216 90373
R102 metal film resistor	95 kΩ	0.1 %	1/8 W	54	4822 116 50438
R103 metal film resistor	980 kΩ	0.1 %	¼ W	54	4822 116 50439
R105 metal film resistor	100 E	0.1 %	0.1 W	54	4822 116 50746
R106-R107-R108 metal film resistor	10 kΩ	0.1 %	0.1 W	54	4822 116 50748
R109-R110 metal film resistor	1.5 kΩ	0.1 %	0.1 W	54	4822 116 50752
R111-R112-R113 metal film resistor	1 kΩ	0.1 %	0.1 W	54	4822 116 50747
R114-R115 metal film resistor	150 E	0.1 %	0.1 W	54	4822 116 50751
R116 metal film resistor	100 E	0.1%	0.1 W	54	4822 116 50746
R118 block resistor	23E08	0.1 %		54	4822 114 10187
R119 block resistor	2E136	0.1 %		54	4822 114 10235
R120 block resistor	2E209	0.1 %		54	4822 114 10236
R121 block resistor	7E110	0.1 %		54	4822 114 10237
R122 block resistor	13E75	0.1 %		54	4822 114 10234
R123 metal film resistor	569 E	0.1 %	0.1 W	54	4822 116 50957
R124 metal film resistor	562 E	0.1 %	0.1 W	54	4822 116 50956
R125-R126 metal film resistor	835 E		0.1 W	54	4822 116 50962
R127 metal film resistor	83E5	0.1 %	0.1 W	54	4822 116 50963
R128 metal film resistor	75E0	0.1 %	0.1 W	54	4822 116 50918
R129 metal film resistor	100 E	0.1 %	0.1 W	54	4822 116 50746
R130-R131 metal film resistor	62E6	0.1 %	0.1 W	54	4822 116 50759
R133 metal film resistor	100 E	0.1 %	0.1 W	54	4822 116 50746
R134 metal film resistor	62E6	0.1 %	0.1 W	54	4822 116 50759
R135-R136 metal film resistor	1.35 kΩ	0.1 %	0.1 W	54	4822 116 50964
R137 metal film resistor	69E0	0.1 %	0.1 W	54	4822 116 50961
R138 metal film resistor	65E7	0.1 %	0.1 W	54	4822 116 50959
R139 metal film resistor	64E9	0.1 %	0.1 W	54	4822 116 50958
R141 metal film resistor	2.15 kΩ	1 %	0.1 W	54	4822 116 50767
R142 metal film resistor	3.83 kΩ	1 %	0.1 W	54	4822 116 50791
R144 metal film resistor	4.02 kΩ	1 %	0.1 W	54	4822 116 50619
R145 metal film resistor	36.5 kΩ	1 %	0.1 W	54	4822 116 50726
R146 metal film resistor	26.4 kΩ	1 %	0.1 W	54	4822 116 51007
R147 metal film resistor	59.0 kΩ	1 %	0.1 W	54	4822 116 50875
R148 metal film resistor	75.0 kΩ	1 %	0.1 W	54	4822 116 50611
R149 metal film resistor	78.7 kΩ	1 %	0.1 W	54	4822 116 50533
R153 metal film resistor	86.6 kΩ	1 %	0.1 W	54	4822 116 50406

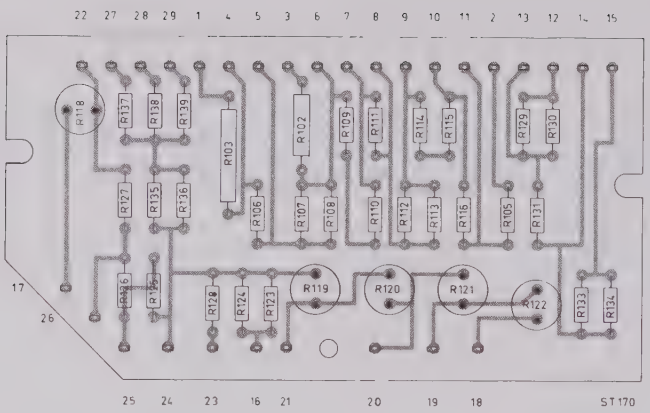

22 27 28 29 1 4 5 3 6 7 8 9 10 11 2 13 12 14 15
R118
R137
R138
R139
R103
R102
R109
R111
R114
R115
R129
R130
R127
R135
R136
R106
R107
R108
R110
R112
R113
R116
R105
R131
R126
R125
R128
R124
R123
R119
R120
R121
R122
R133
R134
17
26
25 24 23 16 21 20 19 18
ST 170

Fig. 40

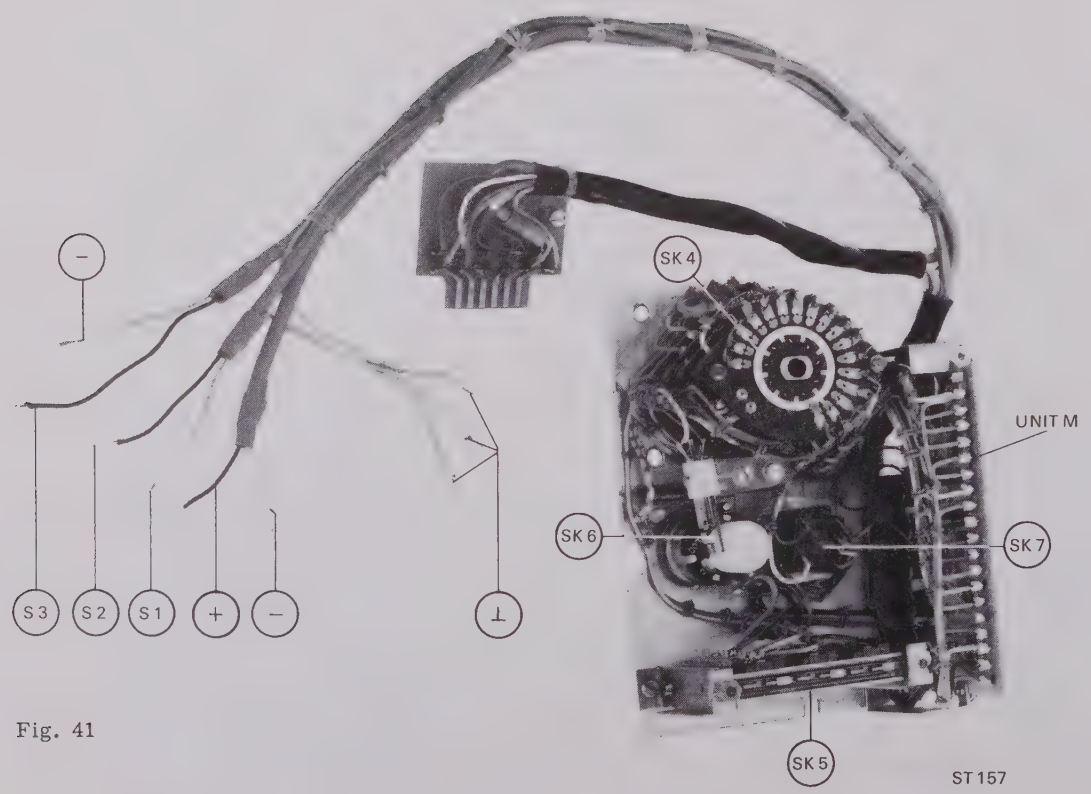

SK 4
UNIT M
SK 6
SK 7
SK 5
S 3
S 2
S 1
+
−
⊥
ST 157

Fig. 41

XII. REPLACING THE DRIVE CORD

A. REMOVING THE CORD

- Turn cord drum (Fig. 43, item 1) until the fixing screw (Fig. 44, item 1) is under the opening (Fig. 44, item 2).
- Loosen the fixing screw and remove the cord extremities.
- If the cord must be replaced, also loosen the fixing screw to the measuring carriage (Fig. 39, item 2).
  When there is a slave potentiometer (Fig. 43, item 2), the fixing screw of the cord in the cord drum (Fig. 43, item 3) must also be loosened.
- The cord can then be removed.

B. MOUNTING THE CORD (without slave potentiometer)

- Open the protection cover, guide the cord through the recesses in the measuring carriage (Fig. 39, item 3) and across the guiding wheels (Fig. 43, item 7). See also Fig. 45.
- Turn the cord drum (Fig. 43, item 1) fully clockwise (seen from the servomotor) and turn it back until the fixing screw (Fig. 44, item 1) is under the opening (Fig. 44, item 2).
- Loosen fixing screw until the cord drum is blocked.
- Lead the cord end, provided with a fixing bush, behind along the cord drum and hook this end in the saw-cut opposite the stop (Fig. 43, item 4).
- Keep the cord tight and check whether it falls into the grooves of the guide wheels.
- Lead the free end of the cord behind the cord drum and turn the fixing screw into the cord drum until it runs free again.
- Turn the cord drum one turn counter-clockwise and fasten the cord extremity with fixing screw.
- The cord must be so taut that the hinge arm of the cord tensioner (Fig. 43, item 5) is in the middle position.
- Close the protective cover and fasten the measuring carriage to the cord so that the pointer can come as far below the beginning as above the end of the scale.
  This distance must be approx. 0.5 mm and can be adjusted with the adjusting screws (Fig. 43, item 6).

C. MOUNTING THE CORD (with slave potentiometer)

- Loosen the two screws in the cord drum of the slave potentiometer (Fig. 43, item 3) and remove the cord drum through the opening (Fig. 44, item 3).
- Fasten the cord according to Fig. 46, to the cord drum and wind it also according to Fig. 46 around the cord drum after which the windings are fastened with an auxiliary tool.
- Slide the cord drum on the spindle of the slave potentiometer.
- Then continue as described under B; ensure that the auxiliary tool is removed from the cord drum before the cord drum (Fig. 43, item 1) is turned one turn counter-clockwise.
- Put the pointer on the zero point of the scale and turn the spindle of the slave potentiometer until the resistance between terminals 1 and 2 (BU13 and BU14) is approx. 20 Ω. When turning the spindle ensure that the cord drum of the slave potentiometer is not turned also.
- Tighten the two screws on the cord drum.

Description	Fig.	Service code number
Drive cord per metre		4822 321 30042
Fixing bush for cord		4822 529 50074
Guide wheel	43 - 7	4822 528 80309
Spindle for guide wheel		4822 535 80375
Tension spring	43 - 8	4822 492 30672
Hinge arm	43 - 5	4822 417 10219

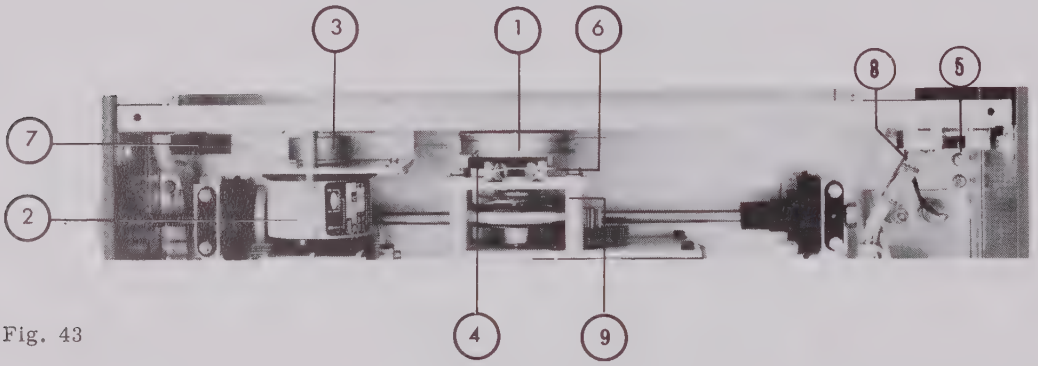


Fig. 43

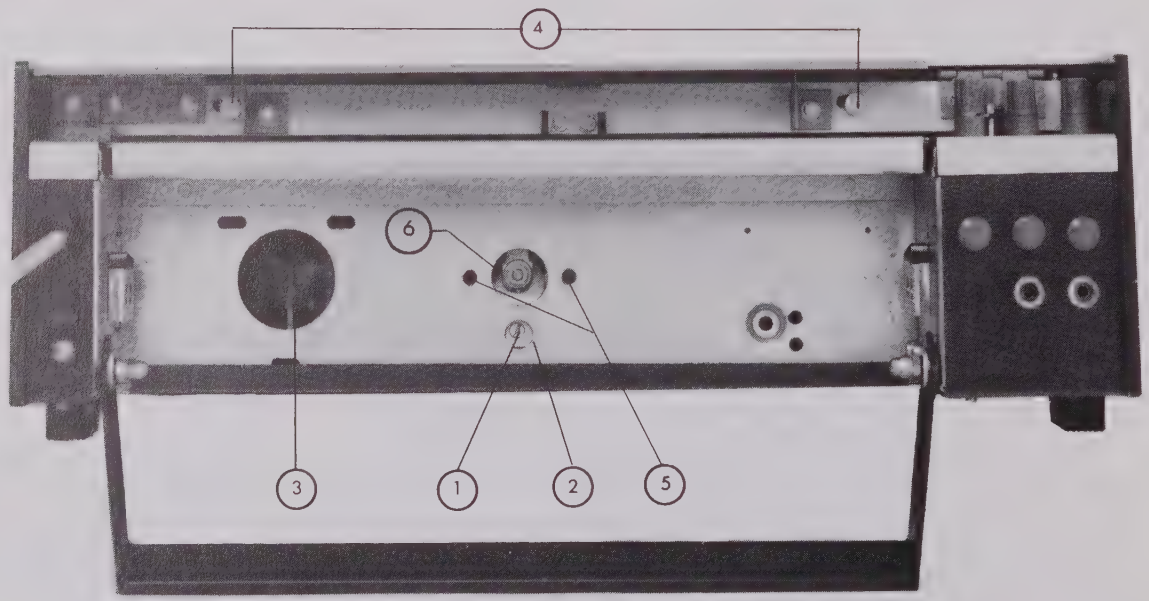


Fig. 44

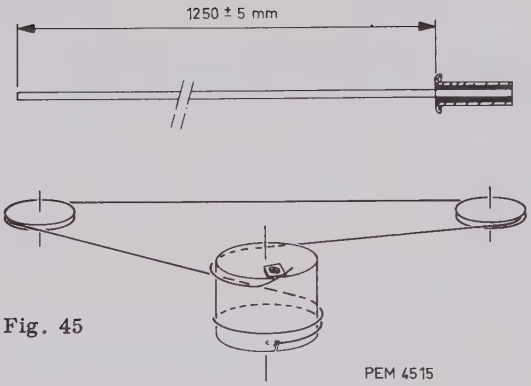
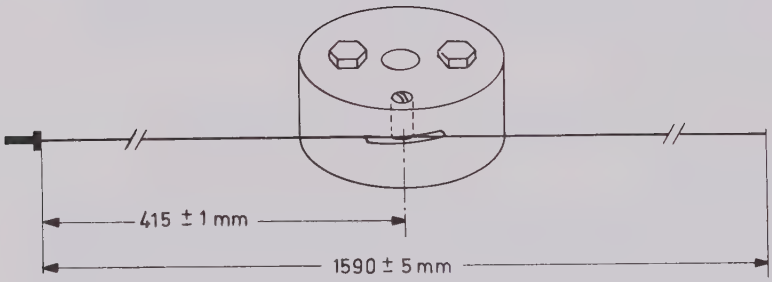


Fig. 45



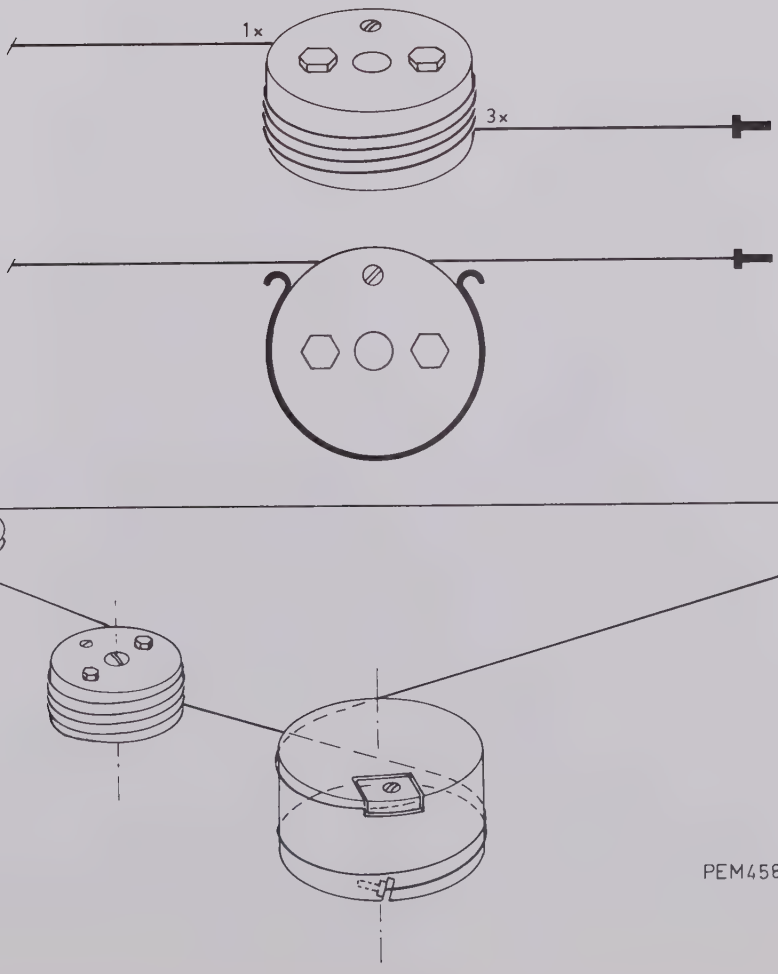


Fig. 46

XIII. MOTOR GENERATOR UNIT

The motor-generator unit consists of the following parts:

A. The motor-generator

B. The reduction unit

A. THE MOTOR-GENERATOR

1. Removing the motor-generator

- Remove the roll of recording chart from the recorder.
- Turn the cord drum until the two holes are appearing under the holes in the partition wall, see fig. 44 pos. 5, now screw two screws M3 in the cord drum.
  The nut, fig. 44 pos. 6 should now be unscrewed and both screws M3 are screwed until the cord drum is clamped to the partition wall.
- Remove the four Allen bolts (Fig. 47, item 1) so that the motor-generator unit can be taken out of the recorder.

Note: In the majority of instruments one of the four Allen bolts is replaced by a threaded rod with which the motor-generator is fixed to the screen.

- The reduction unit can be removed by turning the four Allen bolts (Fig. 47, item 2).

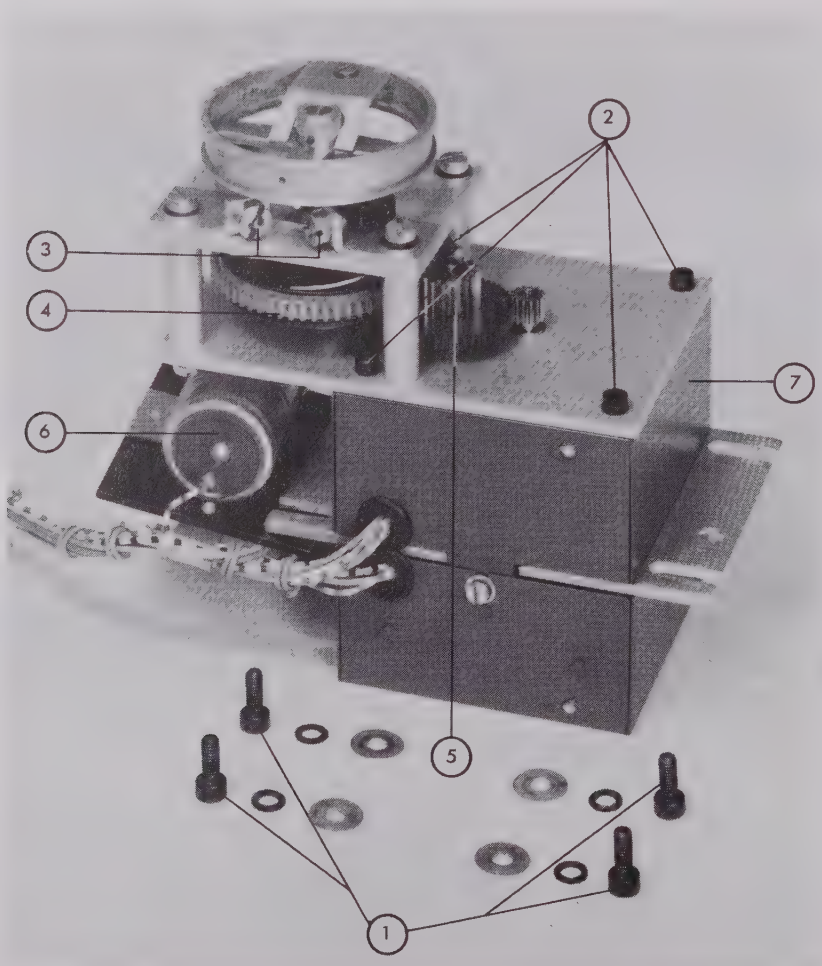


Fig. 47

2. Mounting the motor-generator

- Fasten the reduction unit to the motor-generator with the aid of the four Allen bolts.
- Place the motor-generator on the corner pieces and mount the four Allen bolts.
- Remove the two screws M3.
- Lower the cord drum on the reduction unit and fix the nut, fig. 44 pos. 6.
- Adjust the stops (Fig. 47, item 3) so that the pointer can not pass the beginning and the end of the scale more than approx. 0.5 mm.

B. THE REDUCTION UNIT

1. Dismounting and mounting the reduction unit

- Remove the motor-generator unit as described under A-1
- The reduction unit can then be dismounted and mounted according to Fig. 48.
- For further mounting reference can be made to A-2.

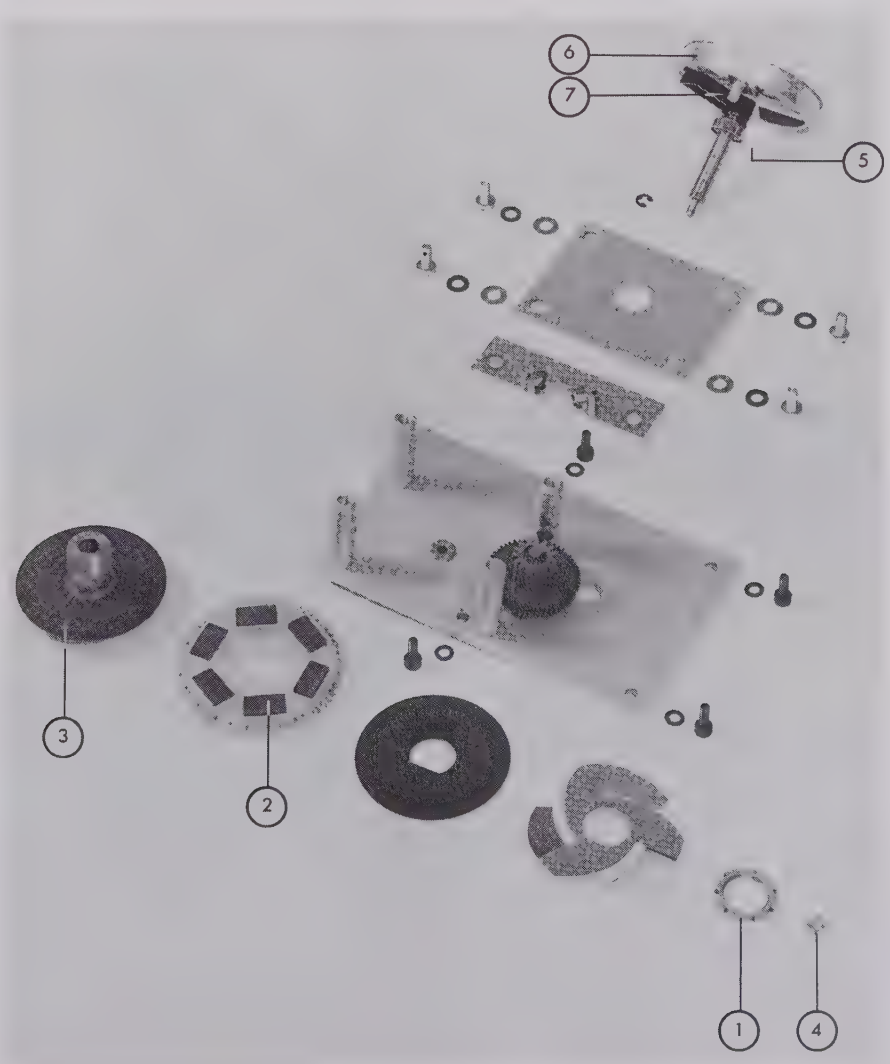


Fig. 48

2. Adjusting the slip coupling

- Short-circuit the input terminals "+" and "-" (BU5 and BU6)
- Press pushbutton -100 % of SK5 ("ZERO")
- Press button "STAND BY".
- Slide the measuring carriage to the end of the scale and press again button "STAND BY". When the measuring carriage runs at the beginning of the scale against the stop the slip wheel (Fig. 47, item 4) must make still approx. 1 revolution before it comes completely into rest position.
  The slip power should be adjusted with the hook-spanner nut (Fig. 43, item 9) and Fig. 48, item 1.

Description	Fig.	Service code number
DRIVE MEASURING CARRIAGE		
Motor-generator 50 c/s	47 - 7	4822 361 40019
Motor-generator 60 c/s	47 - 7	4822 361 40018
Gear wheel	47 - 5	4822 522 20763
Nylon gear wheel 60 teeth	47 - 4	4822 522 30762
C28 condensator 0.33 μF	47 - 6	4822 120 50147
Slipping pad	48 - 2	4822 466 90474
Slip plate	48 - 3	4822 528 20116
Locking piece	48 - 4	4822 466 80323
Ball bearing	48 - 5	4822 520 20145
Cord drum	48 - 6	4822 528 80423
Stop for drum	48 - 7	4822 404 50261

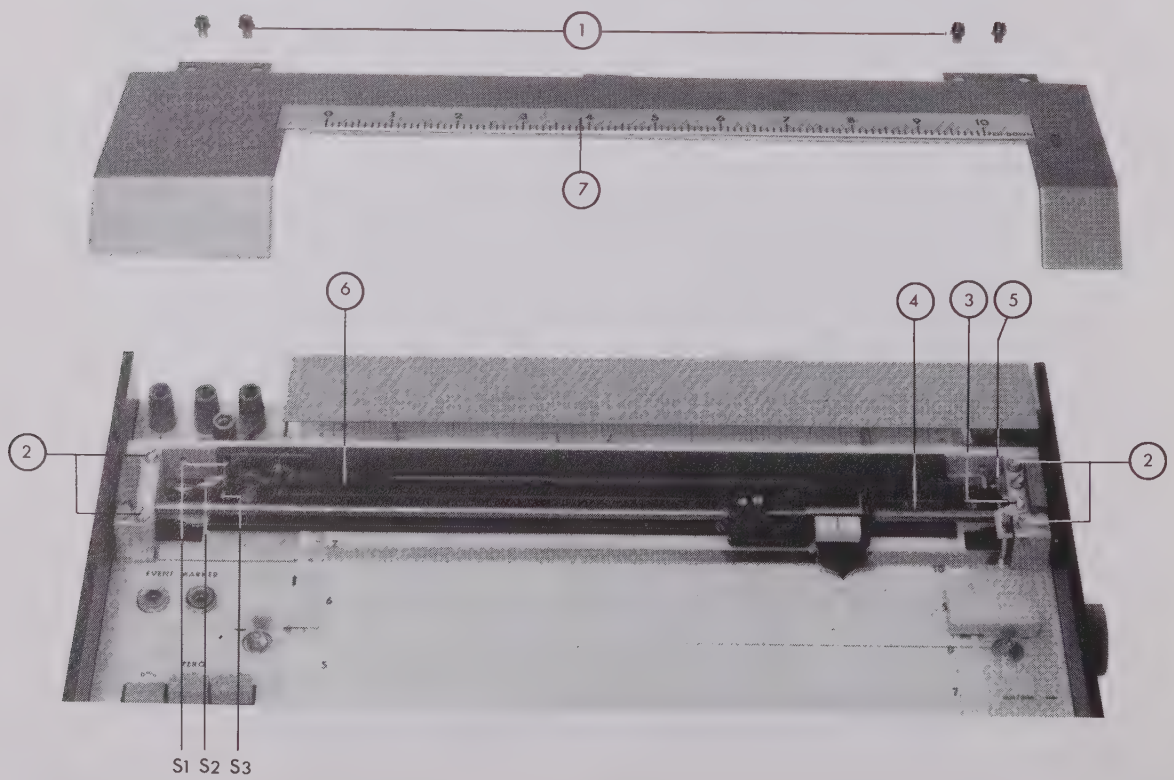


Fig. 49

XIV. THE MEASURING CARRIAGE

A. REPLACING THE MEASURING CARRIAGE

- Take the protective cover from the instrument after the four screws (Fig. 49, item 1) have been removed.
- Unscrew the four screws (Fig. 49, item 2) out of the supporting blocks.
- Loosen the screw (Fig. 49, item 3) with which the spindle (Fig. 49, item 4) is attached a few turns.
- Loosen the screws (Fig. 50, item 1) a quarter of a turn.
- Raise the measuring potentiometer and take the pen holder (Fig. 50, item 2) from the measuring carriage.
- Slide the spindle (Fig. 49, item 4) to the right until the measuring carriage can be taken from the spindle.

Note: When mounting the measuring carriage first loosen the screws (Fig. 50, item 1) a quarter of a turn and remove the pen holder (Fig. 50, item 2). Furthermore, the above operations should be carried out in reverse order.

B. CONTACT SPRINGS

To replace the contact springs (Fig. 50, item 3), the screws (Fig. 50, item 4) must be removed, after which the contact springs can be taken out of the measuring carriage.

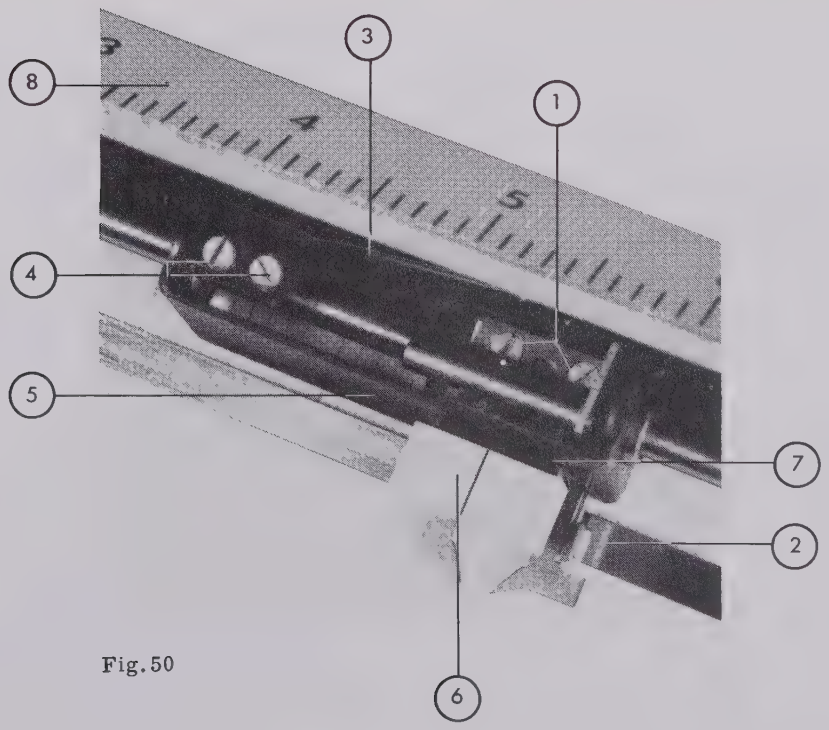


Fig. 50

XV. THE MEASURING POTENTIOMETER

DISMOUNTING AND MOUNTING

- Remove the protective cover by loosening the four screws (Fig. 49, item 1).
- Unsolder the points S1, S2 and S3 (Fig. 49).
- Unscrew the four screws (Fig. 49, item 2) out of the supporting blocks.
- Loosen the screw (Fig. 49, item 3) a few turns, raise the measuring potentiometer and slide the spindle (Fig. 49, item 4) out of the supporting blocks.
- The measuring potentiometer can then be taken fully out of the instrument.
- Remove the two screws (Fig. 44, item 4) and the screw (Fig. 49, item 5), after which the measuring potentiometer can be removed.

The mounting of the new measuring potentiometer must be carried out in reverse order. When the potentiometer has been mounted the zero points should be adjusted according to chapter XI-B.

Description	Fig.	Service code number
MEASURING POTENTIOMETER-MEASURING CARRIAGE		
Guide shaft	49 - 4	4822 535 90736
R41, 42 measuring potentiometer	49 - 6	4822 104 90008
Measuring carriage	50 - 5	4822 464 90061
Contact spring	50 - 3	4822 492 61193
Pointer	50 - 6	4822 450 80307
Pointer bracket	50 - 7	4822 404 50469
Scale	50 - 8	4822 450 30061

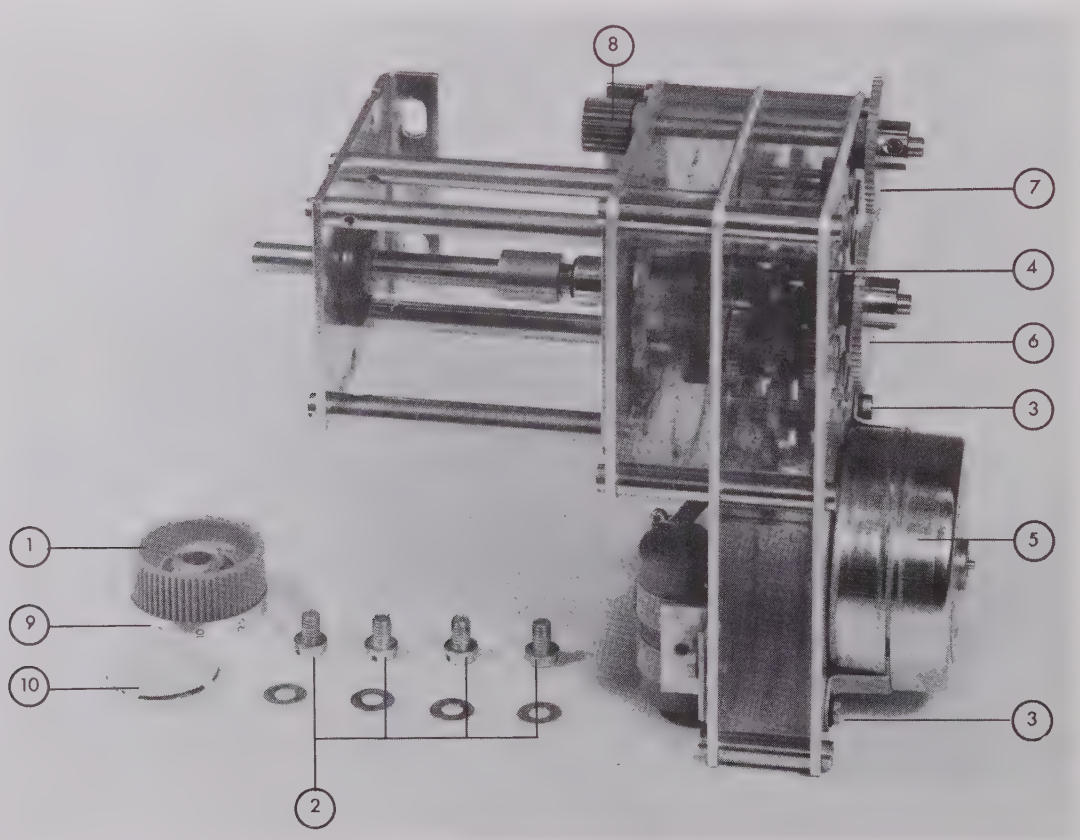


Fig. 51

XIV. CHART DRIVE MECHANISM

The chart transport mechanism is composed of the following:

A. The gear box

B. The chart motor

C. The sprocket shaft

A. THE GEAR BOX

The gear box can be taken out of the recorder by:

- removing the knob (Fig. 51, item 1)
- loosening the four screws (Fig. 51, item 2)
- loosening the wires mounted on switch SK1.

B. CHART MOTOR

The chart motor can be mounted and dismounted by tightening and loosening fixing screws (Fig. 51, item 3) resp. With the mounting of the motor ensure that there is some play between the motor pinion and the driven gear wheel.

C. THE SPROCKET SHAFT

Before removing the sprocket shaft, the motor-generator must first be removed according to chapter XIII and the gear box according described above.
The sprocket shaft can then be removed, see Fig. 52.
When mounting the sprocket shaft the locking strips (Fig. 52, item 1) must not be pulled too tight. The sprocket shaft must be able to be lifted just a little bit against the pressure of the locking strips.

D. THE GUIDING DEVICES

The guiding devices may be simply taken from the recorder by removing the screw, fig. 52a pos. 1.
The guiding devices should also be assembled according to this figure.
It should be attended to that the distance A is adjusted by means of the screw pos. 2, to 0.2 + 0.1 mm, thereafter the adjusting screw is locked by means of locking paint.
During the adjustment no recording chart should be put on the recorder.

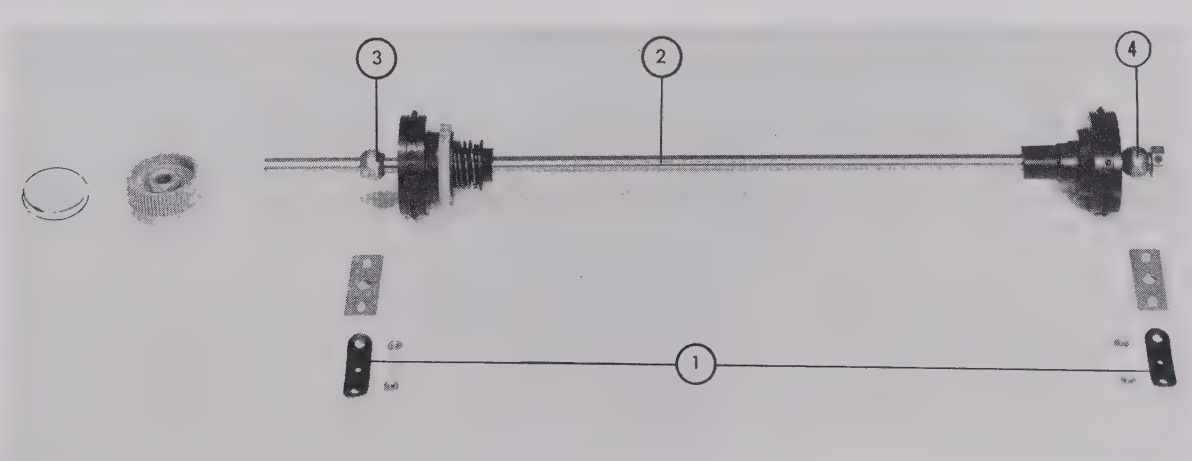


Fig. 52

DRIVE RECORDING CHART

Description	Fig.	Pos.	Service code number
Gear box with motor 50 c/s	51	4	4822 522 10097
Gear box with motor 60 c/s	51	4	4822 522 10119
Chart motor AU 5050/02	51	5	4822 361 60087
Pinion for motor 28 teeth	-	-	4822 522 30767
Gear wheel 65 teeth 50 c/s	51	6	4822 522 30764
Gear wheel 75 teeth 60 c/s	51	6	4822 522 30828
Gear wheel 52 teeth 50 c/s	51	7	4822 522 30765
Gear wheel 72 teeth 60 c/s	51	7	4822 522 30829
Pinion 20 teeth	51	8	4822 522 30766
Knob	51	1	4822 413 40357
Indication strip	51	9	4822 450 30055
Lid for knob	51	10	4822 413 70054
Sprocket shaft (one spherical bearing right)	52	2	4822 522 30768
Spherical bearing right	52	4	4822 520 30111
Spherical bearing left	52	3	4822 520 30176
Leaf spring	52	1	4822 492 61188
Spring for hanging supply roller	20	1	4822 492 61593
Guiding device left	19	2	4822 693 90268
Guiding device right	19	2	4822 693 90267

MISCELLANEOUS

BU8 terminal	7		4822 290 40065
BU5-6-7 terminal	7	+, -, ⊥	4822 290 40011
BU9 to BU15 contact sockets	13		4822 267 30045
Mains cable per metre	2	1	4822 323 40003
Contact stop Eur. version	2	1	4822 264 30007
Mains cable complete Am. version	-	-	4822 321 10104
Relief grommet	16	4	4822 325 60119
Mounting support			4822 290 60029
Fuse holder	16	3	4822 256 40026
SK1 pushbutton switch	16		4822 276 40153
SK3 slide switch (110-220 V)	16	1	4822 277 20014
Foot			4822 462 70551
Friction ring for carrying handle			4822 532 50822
Indication Lamp "POWER ON"	—	—	4822 134 40247

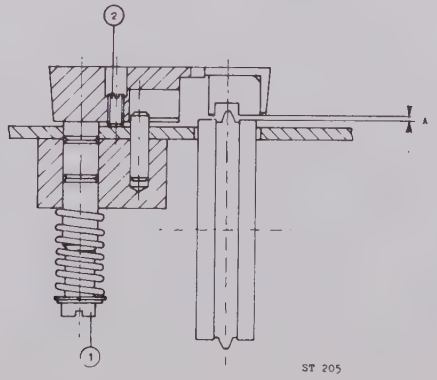


Fig. 52a

XVII. THE VERSION FOR 60 c/s (PM 8100/Q.)

In the chapter below the modifications of the 60 c/s version are given according to the version for 50 c/s.

If ordering a recorder for 60 c/s (PM 8100/Q.) these modifications have been made already on delivery.

When a 50 c/s instrument has to be used on 60 c/s following modifications must be introduced.

- Type number plate
- Mains cable with Am. mains plug 4822 321 10104
- Motor-generator 60 c/s version 4822 361 40018
- Gearbox chart drive complete 4822 522 10119

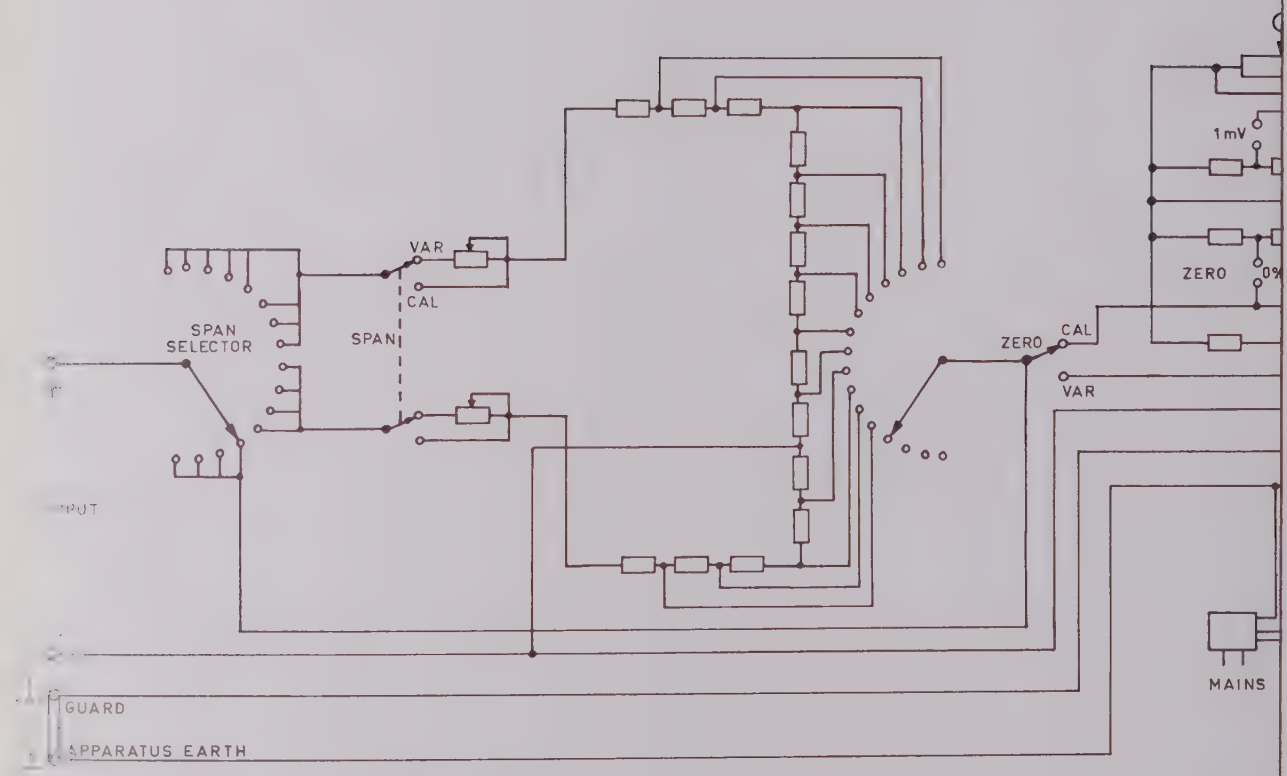
  From this gearbox only the outgoing gears are changed

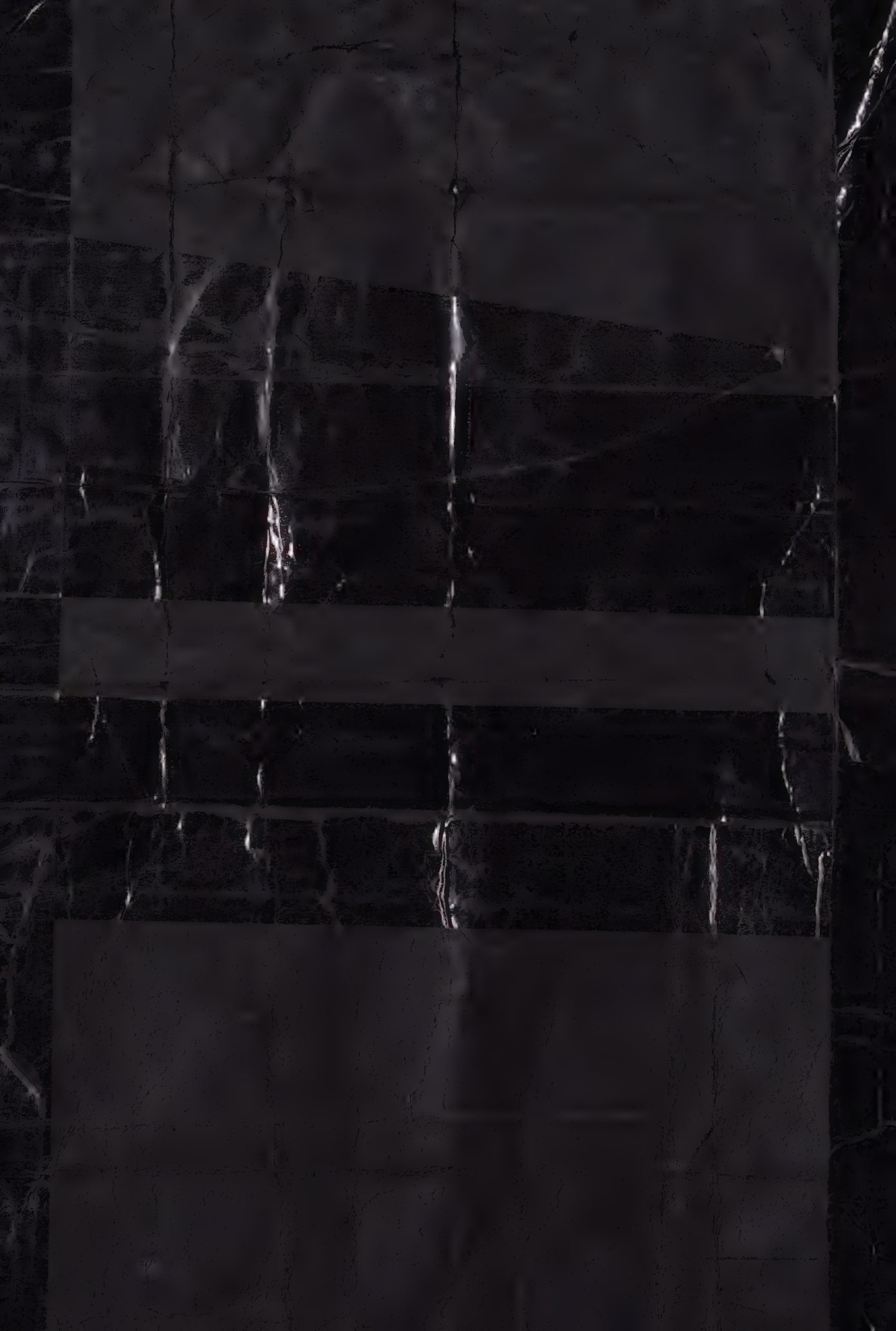
  75 teeth instead of 65 teeth 4822 522 30828

  72 teeth instead of 52 teeth 4822 522 30829

- Unit J	C19	0.082 μF
- SK4	R143	4k22
	R144	4k22
	R146	51k1
	R147	64k9
	R148	78k7
	R149	86k6
	R150	7k15
	R151	28k7
	R152	64k9
	R153	90k9

N.B.: R143 must be connected between point 3 of SK4 and the point R142-R144. Disconnect the short circuit between the points 2 and 3 of the switch SK4. If the damping is not constant within 1% on the positions 20 mV to 100 V of switch SK4 (SPAN), the value of the resistors R141 to R153 should be adapted.


VAR
CAL
SPAN
SPAN SELECTOR
1mV
ZERO
0%
ZERO
CAL
VAR
MAINS
GUARD
APPARATUS EARTH



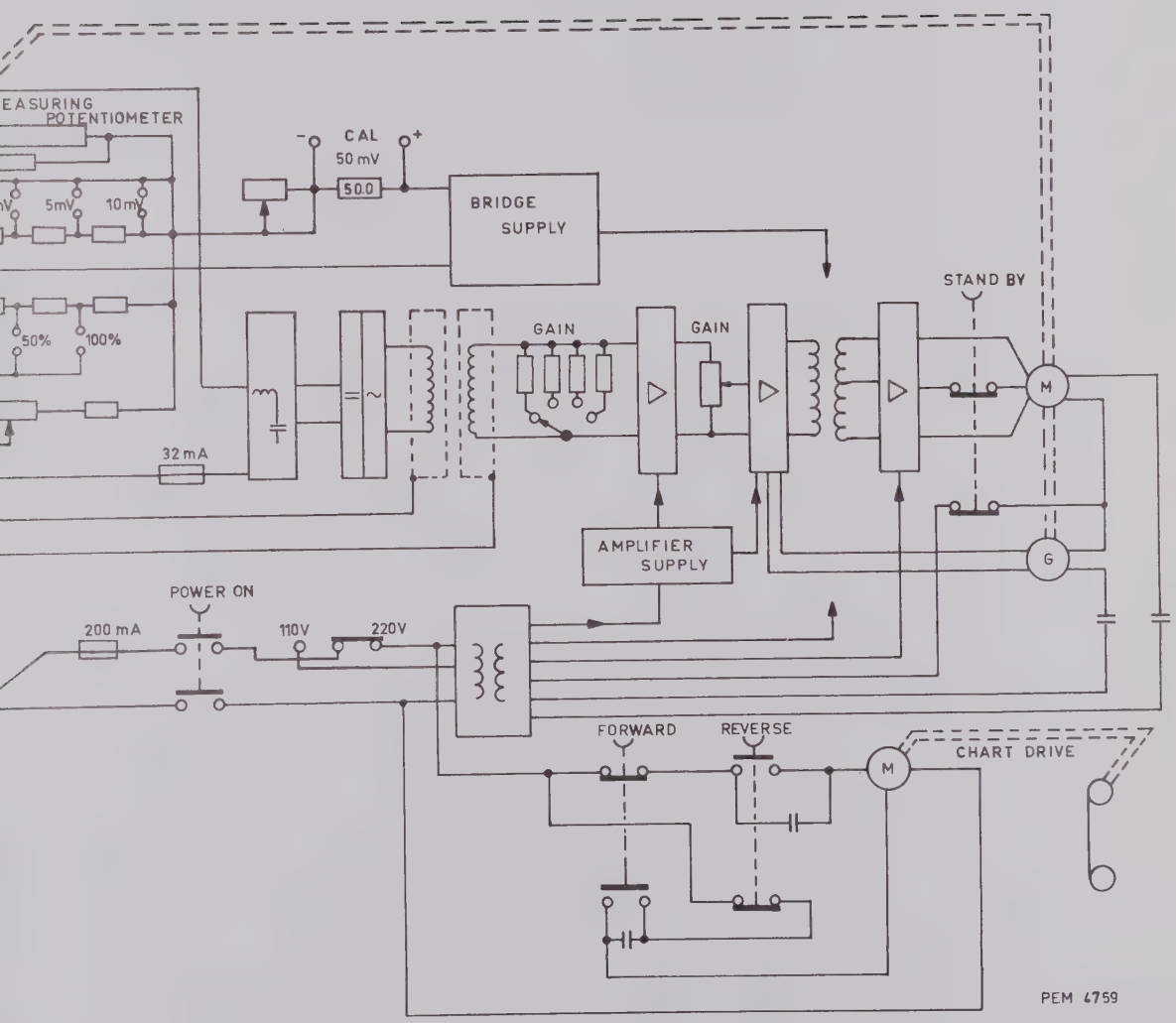

EASURING
POTENTIOMETER
5mV
10mV
50%
100%
32 mA
CAL
50 mV
50.0
BRIDGE
SUPPLY
GAIN
GAIN
STAND BY
M
G
AMPLIFIER
SUPPLY
POWER ON
200 mA
110V
220V
FORWARD
REVERSE
M
CHART DRIVE
PEM 4759

Fig. 53

UNIT F

UNIT E'

UNIT H

UNIT B

UNIT J

UNIT M

"GAIN"

SK4/S4F

SK4/S4R

SK4/S3F

SK4/S2F

SK4/S1R

SK2

SK6

SK7

T1

S1

S2

RE1

TS1 BC109

TS2 BC109

TS3 BC109

GR17 OA 202

GR18 OA 202

GR1 OA202

GR2 OA202

BU3/B

BU3/C

BU3/A

BU3/1

BU3/2

BU3/3

BU3/D

BU3/4

BU4

BU5

BU6

BU7

BU8

VL4 32mA

R51 220

R4 1K

C3 39K 82K

C4 10K 33K

C5 20K 180K

C1 4.7µF

C2 4.7µF

C23 16µF (G)

C22 16µF (G)

R1 100

T5/S2

R49 47

R48 2K

R47 18K

R46 39K

R45 47K

R44 39K

C19 20K

R2 1K78

R3 9K09

C7 80µF (E)

R6 10K

R10 38K3

R5 3K83

C8 10µF (E)

C10 250µF (E)

C33 0.33µF

R7 17K8

R8 5K62

C6 100K

R150 7K2

R151 33K

R152 68K

R153 86K6

C32 100K

R104 2M

VAR

CAL

R101 200K

R105 100

R116 100

R115 150

R114 150

R113 1K

R112 1K

R111 1K

R110 1K5

R109 1K5

R108 10K

R107 10K

R106 10K

R103 980K

R102 95K

R123 569

R124 562

R119 2,136

R120 2,209

R121 7110

R128 756.0

R125 835

R126 935

R129 100

R130 62.6

R131 62.6

R132 3K3

1mV

2mV

-100 %

	CARBON – 1 W – 5 %
	CARBON – 0.5 W – 1 %
	CARBON – 0.25 W – 5 %
	CARBON – 0.125 W – 5 %
	WIRE – WOUND – 0.4 ... 1.8 W – 0.5 %
	POLYESTER – 400 V
	METALLISED POLYESTER – 250 V
	TUBULAR CERAMIC – 500 V
	PAPER – 1000 V
	MINIATURE ELECTROLYTIC (E=16 V, F=25 V, G=40 V, H=64 V)

WIRING COLOUR CODE	
0	BLACK
1	BROWN
2	RED
3	ORANGE
4	YELLOW
5	GREEN
6	BLUE
7	VIOLET
8	GREY
9	WHITE
E.G.: 4/5	YELLOW/GREEN

PM 8100/06/07/08

AMPLIFIER UNIT

10 9 8 7 6 5 4 3 2 1

L K J H F E D C B A

BU4

T5

TS10

TS9

UNIT H

UNIT D

UNIT C

UNIT F

UNIT A

UNIT E

UNIT G

UNIT J

R38

R39

R35

T2

T3

T4

RE1

R43

VL4

GR13

BU1

BU2

BU3

R30

R31

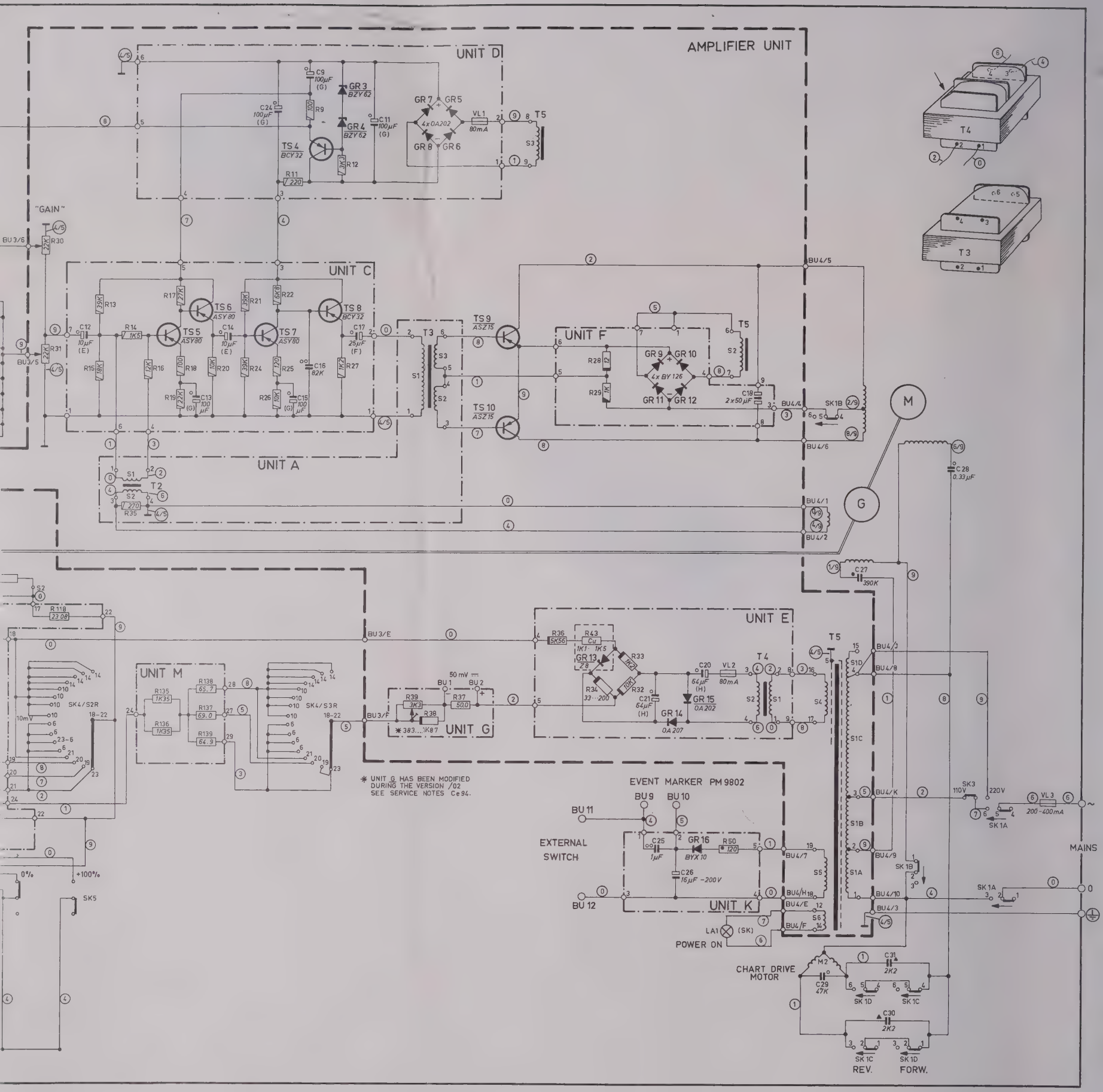
SK2

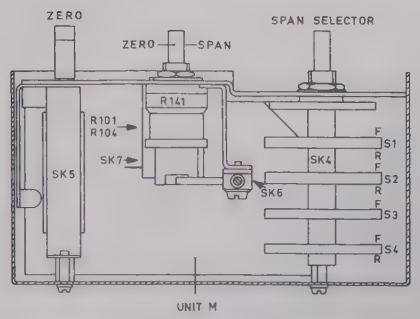
TS1 ··· TS8

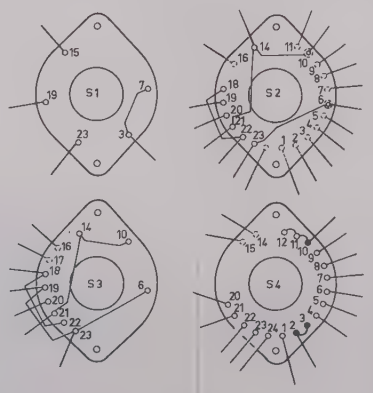
T1

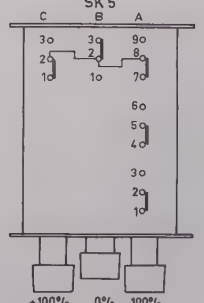
SK2

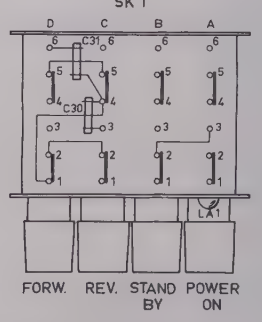
RE1


AMPLIFIER UNIT
UNIT D
UNIT C
UNIT A
UNIT F
UNIT E
UNIT M
UNIT G
UNIT K
"GAIN"
T4
T3
T5
T2
TS4 BCY32
TS5 ASY80
TS6 ASY80
TS7 ASY80
TS8 BCY32
TS9 ASZ15
TS10 ASZ15
GR 3 BZY62
GR 4 BZY62
GR 5
GR 6
GR 7
GR 8
4x0A202
GR 9
GR 10
GR 11
GR 12
4x BY 126
GR 13
GR 14 OA 207
GR 15 OA 202
VL1 80mA
VL2 80mA
VL 3 200-400mA
M
G
BU3/6
BU3/5
BU3/E
BU3/F
BU4/5
BU4/4
BU4/6
BU4/1
BU4/2
BU4/J
BU4/8
BU4/K
BU4/7
BU4/9
BU4/H
BU4/E
BU4/F
BU4/10
BU4/3
SK1B
SK1A
SK1C
SK1D
SK3
SK4/S2R
SK4/S3R
SK5
50 mV
* 383....1K87
* UNIT G HAS BEEN MODIFIED DURING THE VERSION /02 SEE SERVICE NOTES Ce94.
EVENT MARKER PM 9802
BU 9
BU 10
BU 11
BU 12
EXTERNAL SWITCH
LA1 (SK)
POWER ON
CHART DRIVE MOTOR
MAINS
220V
110V
0%
+100%
REV.
FORW.


ZERO
SPAN
ZERO
SPAN SELECTOR
R141
R101
R104
SK7
SK5
SK6
SK4
S1
S2
S3
S4
UNIT M


S1
S2
S3
S4


SK 5
+100%
0%
-100%


SK 1
FORW.
REV.
STAND BY
POWER ON
LA1

ST210

Fig. 54

DELTA ELECTRONIC INSTRUMENTS INC.
A NORTH AMERICAN PHILIPS COMPANY
224 DUFFY AVENUE
HICKSVILLE, NEW YORK 11802